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PREY LANG EXTENDED LANDSCAPE CAMERA TRAP SURVEY

JUNE 2023

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Cover photo: Female long-tailed macaque carrying her baby in Prey Lang, March 2021.

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DISCLAIMER

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

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ACRONYMS AND ABBREVIATIONS

CI	Confidence Interval
GPL	Greening Prey Lang
IUCN	International Union for Conservation of Nature
KDE	Kernel Density Estimation
KPT	Kampong Thom
PDoE	Provincial Department of Environment
PLEL	Prey Lang Extended Landscape
Prey Lang	Prey Lang Wildlife Sanctuary
Phnom Thnout	Phnom Thnout-Phnom Pok Wildlife Sanctuary
PVH	Preah Vihear
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SECR	Spatially Explicit Capture-Recapture
STR	Stung Treng
USAID	United States Agency for International Development

EXECUTIVE SUMMARY

- This camera trap survey pilot is **the first study in Cambodia to apply camera trap distance sampling** to multiple species over a broad geographic scale. It efficiently provided **baseline estimates on population and distribution** of multiple terrestrial species in Prey Lang Wildlife Sanctuary, presented in this document.
- A total of **54 species** was recorded, including **19 species of mammals, 34 species of wild birds,** and **1 species of reptile**. **Eight species** are listed on the International Union for Conservation of Nature (IUCN) Red List (**four vulnerable** and **four endangered** species).
- Distribution maps and graphical displays of activity patterns were produced for **13 wildlife species.** Population estimates were produced for **four species** (variable squirrel, Berdmore's squirrel, Siamese fireback, and wild pig).
- Population estimates for two species of squirrels are the **first ever obtained in Southeast Asia** (see Table 1).
- Ungulate populations are under **severe threats** in Prey Lang, especially hunting with snares and dogs. Despite species such as wild pig and northern red muntjac being robust to hunting and relatively resilient, their low encounter rate suggests the **hunting pressure is high** in Prey Lang and is likely having a **significant impact** on their population. Such low density of ungulates is serious and alarming and the protected area management authorities should address this issue and identify measures to stop poaching and support recovery.
- Tropical pheasants are difficult to survey due to their cryptic behavior and their lack of unique identification markings. The research team managed to produce **distribution and abundance estimates for Siamese firebacks**. This represents the **first population estimate for this species in Cambodia,** demonstrating the value of this methodology to survey tropical Asian Galliformes in Cambodia.
- To reduce ongoing threats of both hunting and habitat loss, **strong protected area management** is required. Regular monitoring of terrestrial species using **robust methodology** is therefore essential to first assess the impacts of threats to wildlife, as well as for effective planning and management interventions.
- The results highlight that despite wildlife protection efforts, **hunting has severely impacted** populations of terrestrial mammals. **Significant efforts as well as immediate actions are needed, and new measures should be adopted by the protected area management authorities to allow species to recover in this landscape and avoid extirpation.**

Table 1: Population Estimates of Four Wildlife Species in Prey Lang Wildlife Sanctuary

Species	Density in Individuals per km² (95% CI)	Number of Individuals (95% CI)
Variable squirrel	0.53 (0.34–0.83)	1,276 (823–2,010)
Berdmore's squirrel	0.23 (0.09–0.45)	553 (218–1,090)
Siamese fireback	0.24 (0.06–0.48)	593 (145–1,163)
Wild pig	0.09 (0.04–0.22)	226 (97–533)

CI: Confidence Interval.

សេចក្តីសង្ខេប

- ការដាក់កាមេរ៉ាស្វ័យប្រវត្តិសាកល្បងដោយប្រើប្រាស់វិធីសាស្ត្រប្រមូលទិន្នន័យពីចម្ងាយ គឺជាការសិក្សាលើកដំបូងនៅប្រទេសកម្ពុជាសម្រាប់សត្វព្រៃជាច្រើនប្រភេទនិងទីតាំងធំទូលាយ។ តាមវិធីសាស្ត្រនេះយើងអាចធ្វើការប៉ាន់ប្រមាណនូវទិន្នន័យដើមនៃចំនួនវត្តមាន និងរបាយរបស់ប្រភេទសត្វព្រៃចម្រុះក្នុងដែនជម្រកសត្វព្រៃ ព្រៃឡង់ ដែលមានបង្ហាញនៅក្នុងរបាយការណ៍នេះ។
- កាមេរ៉ាស្វ័យប្រវត្តិ បានចាប់យករូបភាពសត្វព្រៃចំនួន៥៤ ប្រភេទ ដែលក្នុងនោះរួមមានថនិកសត្វ១៩ ប្រភេទ សត្វស្លាប៣៤ប្រភេទ និងសត្វល្មូន១ប្រភេទ។ សត្វព្រៃចំនួន៨ ប្រភេទជាប្រភេទដែលមានកត់ត្រាក្នុងបញ្ជីក្រហម IUCN ដែលបួនប្រភេទកំពុងទទួលរងការគំរាមកំហែងនិង បួនប្រភេទទៀតជាប្រភេទជិតផុតពូជ។
- ដែនទីរបាយសត្វព្រៃ និងក្រាហ្វិកបង្ហាញពីសកម្មភាពត្រូវបានបង្កើតឡើងសម្រាប់សត្វព្រៃចំនួន ១៣ ប្រភេទ។ ការប៉ាន់ប្រមាណចំនួនត្រូវបានធ្វើឡើងសម្រាប់សត្វព្រៃ៤ប្រភេទ (កំប្រុកពណ៍ កង្ហែនស្តេចកូលីត និងជ្រូកព្រៃ)។
- ការសិក្សាអំពីសត្វព្រៃពីរប្រភេទក្នុងអំបូរកំប្រុកគឺជាការសិក្សាលើកដំបូងបង្អស់នៅក្នុងតំបន់អាស៊ីអាគ្នេយ៍ (បង្ហាញក្នុងតារាងទី១)។
- ចំនួនរបស់អំបូរសត្វជើងចំពាមគឺស្ថិតនៅក្រោមការគំរាមកំហែងយ៉ាងធ្ងន់នៅតំបន់ព្រៃឡង់ ជាពិសេសដោយការដាក់អន្ទាក់ និងឆ្កែស្រុក។ ជ្រូកព្រៃ និងសត្វល្លូសគឺប្រភេទសត្វដែលមានការ បរបាញ់ជាខ្លាំង ដែលធ្វើឱ្យអត្រាប្រទះយើញវត្តមានរបស់វាមានតិចក្នុងដែនជម្រកសត្វព្រៃ ព្រៃឡង់។ ការធ្លាក់ចុះនៃអំបូរសត្វជើងជំពាមគឺស្ថិតនៅក្នុងកំរិតមួយដែលត្រូវប្រកាសអាសន្នដែលទាមទារឱ្យមានវិធានការដោះស្រាយជា បន្ទាន់។
- អំបូរមាន់ទោគឺជាប្រភេទសត្វដែលពិបាកក្នុងការសិក្សាដោយសារតែអាកប្បកិរិយារបស់វា និងកង្វះនៃ ការសម្គាល់ជម្រករបស់វា។ យើងបានបង្កើតដែនទីរបាយ និងចំនួនរបស់ស្តេចកូលីត ហើយវាជាការស្រាវជ្រាវត្តមានស្តេចកូលីតជាលើកដំបូងនៅកម្ពុជា ដែលការសិក្សាស្រាវជ្រាវនេះបង្ហាញពីគុណតម្លៃ នៃការប្រើវិធីសាស្ត្រនេះដើម្បីសិក្សាអំបូរមាន់ទោនៅកម្ពុជា។
- ដើម្បីកាត់បន្ថយការគំរាមកំហែង ទាំងការដាក់អន្ទាក់ និងការបាត់បង់ទីជម្រក យើងគួរមានការគ្រប់ គ្រងតំបន់ការពារធម្មជាតិឱ្យច្បាស់លាស់។ ដូច្នេះការត្រួតពិនិត្យទៀងទាត់នៃប្រភេទសត្វនៅលើដី ដោយប្រើវិធីសាស្ត្រច្បាស់លាស់ គឺជាការចាំបាច់ដើម្បីវាយតម្លៃពីផលប៉ះពាល់នៃការគំរាមកំហែង ដល់សត្វព្រៃក៏ដូចជាសម្រាប់ការធ្វើដែនការ និងអន្តរាគមន៍គ្រប់គ្រងប្រកបដោយប្រសិទ្ធភាព។
- លទ្ធផលបានគូសបញ្ជាក់ថា ទោះបីជាមានការខិតខំប្រឹងប្រែងការពារយ៉ាងណាក៏ដោយក៏ចំនួននៃថនិកសត្វនៅលើដីត្រូវបានរងការគំរាមកំហែងយ៉ាងធ្ងន់ធ្ងរដោយការបរបាញ់។ កិច្ចខិតខំប្រឹងប្រែង សំខាន់ៗក៏ដូចជាវិធានការជាបន្ទាន់គឺត្រូវការចាំបាច់ ហើយវិធានការថ្មីគួរតែត្រូវបានប្រើប្រាស់ដោយ អជ្ញាធរគ្រប់គ្រងតំបន់ការពារធម្មជាតិ ដើម្បីស្តារវត្តមានប្រភេទសត្វព្រៃឡើងវិញនៅក្នុងតំបន់ទេសភាពនេះ និងជៀសវាងទៅដល់ការផុតពូជ។

តារាងទី ១: ការប៉ានប្រមាណប្រជាការនៃប្រភេទសត្វព្រៃចំនួនបួនប្រភេទក្នុងដែនជម្រកសត្វព្រៃ ព្រៃឡង់

ប្រភេទសត្វ	ដង់ស៊ីតេសតនិមយៗ/ក.ម២ (៩៥ % CI)	ចំនននៃសតនិមយៗ (៩៥ % CI)
កំប្រុកពណ៍	០.៥៣ (០.៣៤-០.៨៣)	១២៧៦ (៨២៣-២០១០)
កង្ហែន	០.២៣ (០.០៩-០.៤៥)	៥៥៣ (២១៨-១០៩០)
ស្តេចកូលីត	០.២៤ (០.០៦-០.៤៨)	៥៩៣ (១៤៥-១១៦៣)
ជ្រូកព្រៃ	០.០៩ (០.០៤-០.២២)	២២៦ (៩៧-៥៣៣)

CI: Confidence Interval.

1.0 PREY LANG WILDLIFE SANCTUARY

Prey Lang Wildlife Sanctuary (Prey Lang) is located in the central plains of Cambodia and extends over four provinces: Kratie, Stung Treng, Kampong Thom, and Preah Vihear. This wildlife sanctuary was created in 2016 and covers an area of nearly 4,320 km².

Prey Lang is one of the most biodiverse forests in Cambodia and provides critical refuge to several threatened species, including Asiatic elephants, pileated gibbons, and banteng. In total, Prey Lang supports nationally and regionally important populations of 55 globally threatened vertebrates (Hayes et al. 2015). The forest is a hugely important place for the conservation of Cambodia's birds, home to nearly 45% of all of Cambodia's bird species, and it remains one of Southeast Asia's last remaining lowland evergreen woodlands.

This protected area plays a central role in the lives of hundreds of thousands of people in Cambodia. More than 250,000 people, including members of the indigenous Kuy people, live in districts surrounding Prey Lang. In the Kuy language, "Prey Lang (ព្រៃឡង់)" means "Our Forest." Most of the people rely directly on the habitat for their subsistence and livelihoods; they have depended upon it for generations and collect resin, building materials, medicine, and food from the forest. Prey Lang is also a major watershed feeding into the Mekong River and Tonle Sap Lake, supporting freshwater fisheries, which is essential to the country's economy and food security.

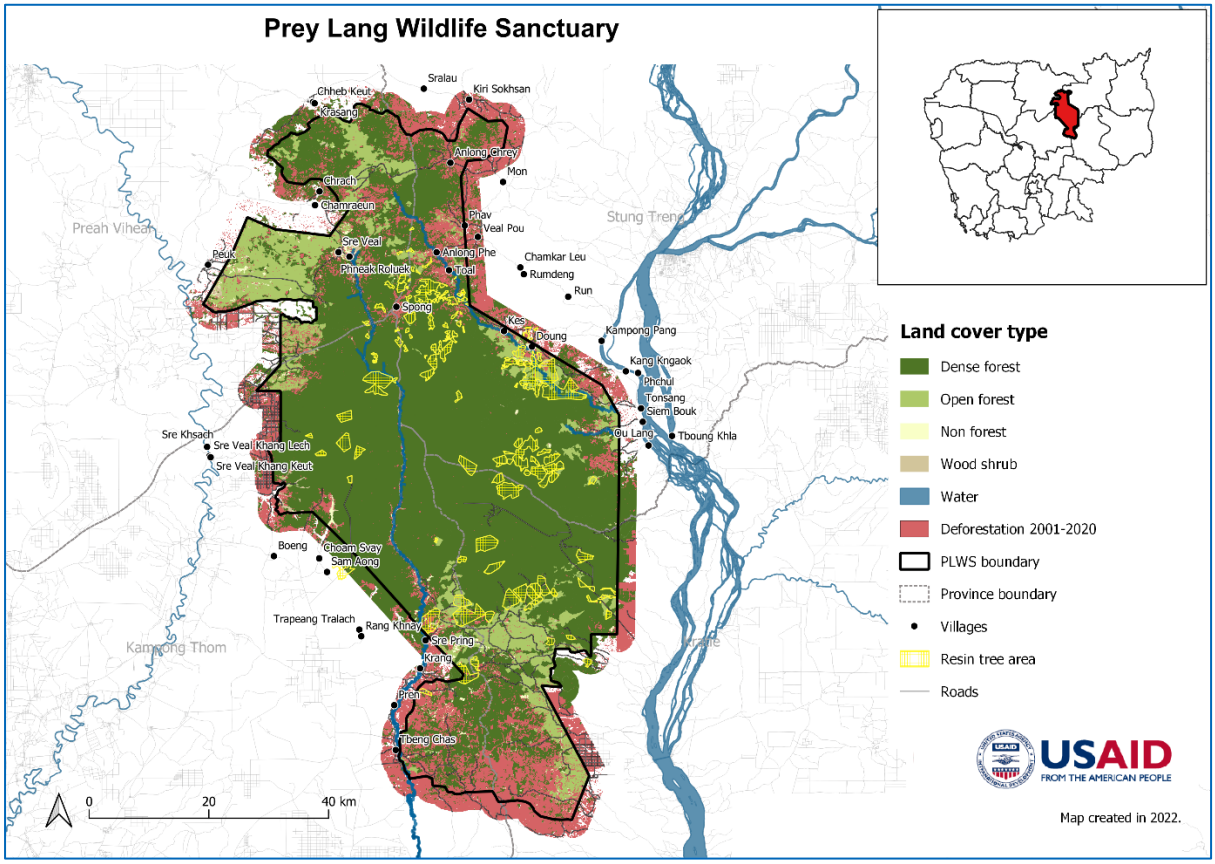

Figure 1: Map with Habitat Types of Prey Lang Wildlife Sanctuary, with an Inset Showing the Location of the Protected Area within Cambodia

2.0 USAID GREENING PREY LANG AND PREY LANG EXTENDED LANDSCAPE CAMERA TRAP SURVEY

United States Agency for International Development (USAID) Greening Prey Lang (GPL) is a five-year Activity that aims to promote resilient, low-emission development and inclusive, sustainable management in the Prey Lang Extended Landscape (PLEL). USAID GPL is led by Tetra Tech with support from two major partners, Wildlife Conservation Society and Conservation International. To achieve this goal, USAID GPL implements an integrated, landscape-level approach that addresses the direct threats to natural capital and their drivers. The Activity improves participation and evidence-based decision-making in Cambodia's management of its forests and biodiversity to lower greenhouse gas emissions, create economic opportunities for rural people, and mobilize investment in natural capital to reduce risks due to climate change vulnerabilities.

The geographic focus of the USAID GPL activity is the PLEL, which is a mosaic of land cover and land use types—protected areas, concessions, and communities—under severe threats from deforestation, wildlife trafficking, and the impacts of climate change. The PLEL is situated across 8.8 million acres (3.5 million hectares) and six provinces (Preah Vihear, Kampong Thom, Kratie, Stung Treng, Siem Reap, and Oddar Meanchey) in north-central Cambodia. It includes natural protected areas (wildlife sanctuaries, natural heritage parks, protected landscapes, Ramsar sites, and multiple use protected areas), community protected areas, community forests, community fisheries, and biodiversity conservation corridors, as well as the catchment basins hydrologically connecting these areas to the Tonle Sap ecosystem.

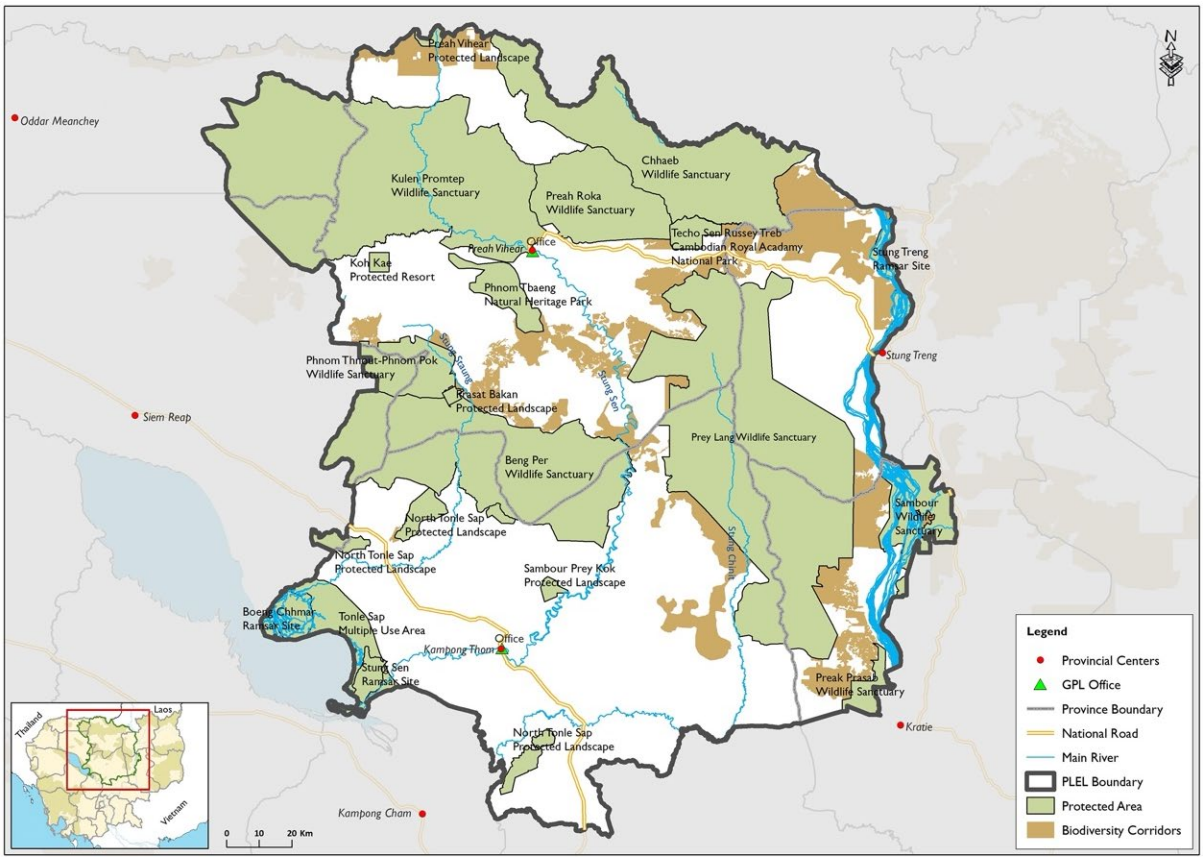

Figure 2: Prey Lang Extended Landscape, including Protected Areas

Camera trapping provides a non-invasive method of monitoring cryptic species in difficult forest environments. Recent developments in camera trapping and subsequent modelling provide a reliable method of estimating population densities and abundances without the need for individual recognition. Population estimates allow identification of trends and changes in populations of wildlife species, and distribution estimates allow for spatial prioritization. Understanding the key species' trends over time is essential for effective planning, management interventions, and assessing project successes.

Four protected areas in the Northern Plains were initially chosen as target sites to conduct a camera trap survey:

- Chhaeb Wildlife Sanctuary
- Preah Roka Wildlife Sanctuary
- Phnom Thnout-Phnom Pok Wildlife Sanctuary (Phnom Thnout)
- Prey Lang Wildlife Sanctuary

The survey in Phnom Thnout was not completed, as the pilot capture rate was low and distance reference data was not collected, limiting the utility of the image data. Phnom Tbaeng Natural Heritage Park was then added as a target site in 2022 to conduct a camera trap survey.

In these protected areas, the current information on the key species in terms of distribution and abundance was limited, and previous survey data did not have enough information to support the zoning process.

The main goal of this camera trap survey was to provide population and distribution data for key terrestrial species to inform protected area management. This survey therefore aimed to:

- Confirm ongoing presence of rare, low-density species;
- Estimate abundance and density for species with sufficiently high encounter rates; and
- Estimate distribution of species with sufficiently high encounter rates.

This report will focus on the PLEL Camera Trap Survey results of Prey Lang Wildlife Sanctuary.

Prey Lang Biodiversity Corridor, 2022

3.0 METHODOLOGY

3.1 CAMERA TRAP DISTANCE SAMPLING

In each protected area, the research team used four systematic and spatially overlapping grids, with the grids labelled as A, B, C, and D. The team used a systematic design with a random origin. This design is robust to camera loss, as each grid provides complete spatial coverage. Each grid was left for a total of 1.5 months, increasing the total number of samples, and allowing the team to change batteries and SD cards.

Table 2: Number of Camera Traps Deployed during the Camera Trap Survey in Prey Lang Wildlife Sanctuary

Wildlife Sanctuary	Grid	Number of Cameras Deployed
Prey Lang Wildlife Sanctuary	A	52
	B	52
	C	51
	D	*Not deployed due to COVID-19 restrictions*
	Total	155

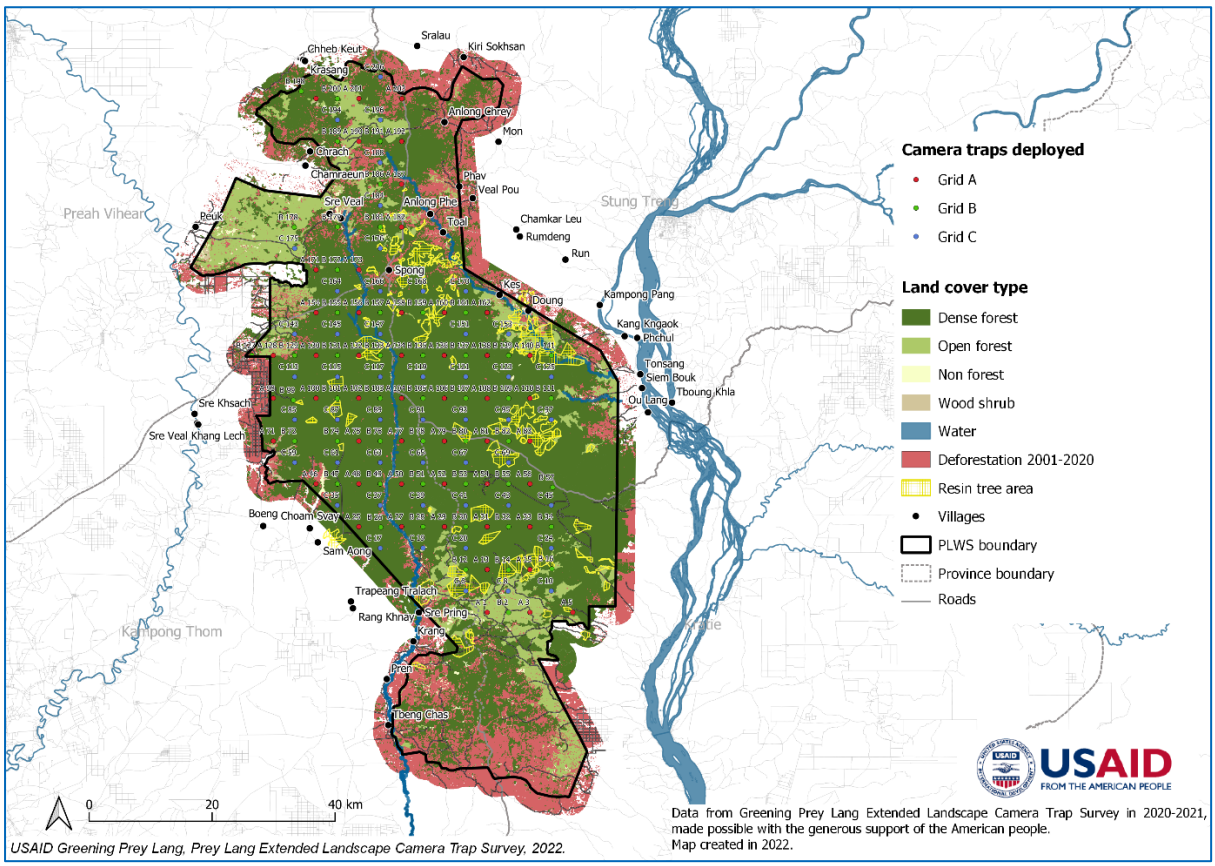

Figure 3: Location of Camera Traps Deployed and Habitat Types in Prey Lang Wildlife Sanctuary

The research team collected camera trap data between January and May 2021. Cameras were programmed to operate all day and to record one photo at each activation, with the minimum triggering interval between activations (0.6 seconds). Each camera was deployed facing north (to avoid backlight), with a tolerance of ±40° if something was blocking the view. Cameras were set up

at a standardized height of 80 cm and angled to be parallel to the slope of the ground. The date and time of capture were automatically stamped onto each image.

Following Howe et al. (2017), reference videos were recorded at each location by holding distance labels at predefined distances from 1 to 12 meters, at 1-meter intervals (until 8 meters) and 2-meter intervals (until 12 meters). Reference videos were taken in the center and at each side of the camera's field of view so that the team could subsequently estimate observation distances to animals moving in front of the camera.

The team estimated distances between cameras and the midpoints of each detected animal in each video at predetermined snapshot moments by comparing animal locations to the distance labels in the reference videos. Predetermined snapshot moments represent observations at specific times of day, with an interval between snapshots "t" set to 2 seconds, a value considered appropriate to obtain adequate sample sizes even for fast-moving and rare species (Howe et al. 2017).

The team corrected for species-specific availability by estimating the proportion of time each species was available for camera detection. Activity level was estimated following Rowcliffe et al. (2014) and using the R package "activity" (Rowcliffe 2023).

Densities were estimated by applying the formula (equation 2) of Howe et al. (2017). The team considered all operational days, excluding days of camera installation and retrieval, when calculating survey efforts. As reactivity to cameras is expected to induce bias (Buckland et al. 2001), the research team discarded all observations where animal behavior indicated a reaction to cameras. The team fitted the detection functions to the remaining estimated distances and calculated species-specific density using R (v4.1.0; R Core Team 2023). Eight models were taken into consideration: the uniform key with 1, 2, and 3 cosine adjustments; the half normal key with 0, 1, and 2 cosine adjustments; and the hazard rate key with 0 and 1 simple polynomial adjustments. As observations were not independent, the team estimated variances using a nonparametric bootstrap, resampling points with replacement, and selected the best models by comparing Quasi Akaike Information Criterion (QAIC), following a two-step method described in Howe et al. (2019). The density estimate could then be multiplied by the survey area to provide an abundance estimate of individuals across the survey area of Prey Lang.

The distribution estimates used independent camera trap observations, adjusted for survey effort, to provide encounter rates for each species. The team used the non-parametric method *kernel density estimation* (KDE) to interpolate encounter rates across the surveyed area and between each camera trap. This method provided distribution estimates at a resolution high enough to inform protected management and to prioritize key areas for conservation efforts. For this analysis, KDE distribution maps were produced using the heatmap (KDE) algorithm for Quantum GIS, version 3.16.4 (QGIS.org 2023).

4.0 RESULTS

4.1 CAMERA TRAP SURVEY IN PREY LANG WILDLIFE SANCTUARY

In Prey Lang, the team deployed a total of 155 cameras over the total trapping period from January 11, 2021, to May 17, 2021. Among the 155 cameras, five were stolen and one memory card was lost. Therefore, 149 cameras were operational during this survey, being active for 8,417 trap nights. More than 125,000 images were recorded, including 7,732 wildlife images.

Four new bird species were recorded during this survey and added to the checklist of Prey Lang: changeable hawk-eagle (*Nisaetus cirrhatus*), blue-and-white flycatcher (*Cyanoptila cyanomelana*), crimson sunbird (*Aethopyga siparaja)*, and greater yellownape (*Chrysophlegma flavinucha*). A checklist represents a list of all species known to occur within a defined area and is a fundamental resource for effective protected area management.

149 operational cameras

8,417 trap nights

445 GB of data

+125,000 images

7,732 wildlife images recorded

33 staff involved in the field

Training on camera trap deployment, 2020

Yellow throated marten

54
wildlife species recorded including

19 mammals

34 birds

1 reptile

Oriental pied hornbill

Bengal monitor

Variable squirrel

Siamese fireback

Wildlife Species

WITH THE HIGHEST ENCOUNTER RATES:

Variable squirrel (កំប្រុកពណ៍)

Berdmore's squirrel (កង្ហែន)

Lesser oriental chevrotain (ក្តាន់ញែងតូច)

Siamese fireback (ស្តេចកូលីត)

Wild pig (ជ្រូកព្រៃ)

Wild pig

8

species on the IUCN Red List of Threatened Species including

4

vulnerable species

- Asiatic Black Bear (ខ្លាឃ្មុំធំ)
- Sambar (ប្រើស)
- Sun Bear (ខ្លាឃ្មុំតូច)
- Binturong (សំពោចភ្នំ)

Sambar

Asian elephant

8

species on the IUCN Red List of Threatened Species including

4

endangered species

- Banteng (ទន្សោង)
- Long-tailed Macaque (ស្វាក្តាម)
- Green peafowl (ក្ងោក)
- Asian elephant (ដំរីអាស៊ី)

Banteng

5.0 SPECIES RICHNESS

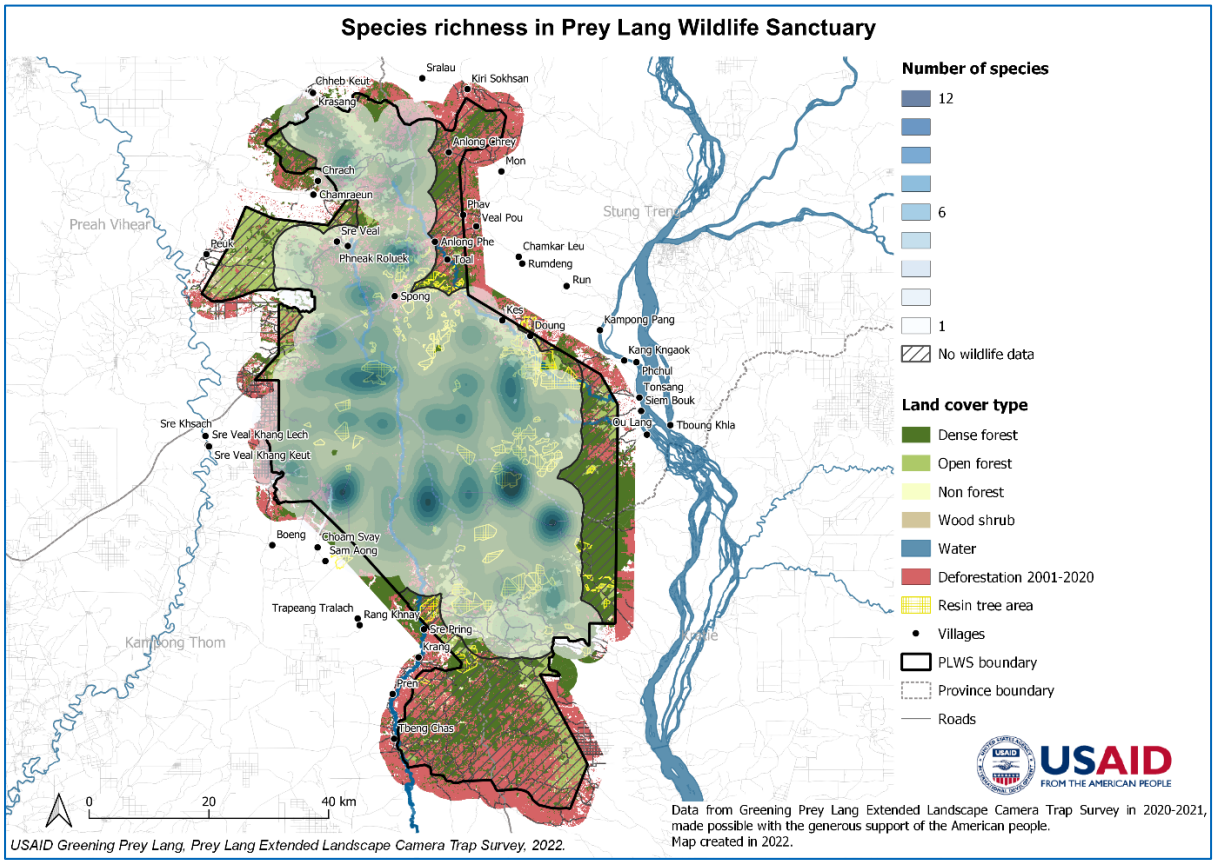

Figure 4: Species Richness in Prey Lang Wildlife Sanctuary

The species richness represented in this map is a measure of diversity that considers only the number of different taxa, not their relative abundance.

In Prey Lang, the highest number of species occur:

- In the central evergreen and semi-evergreen forests, mostly along the river "Steung Chinit (ស្ទឹងជីនិត)";
- Along roads on the east side of the protected area, nearby the Mekong River; and
- In more disturbed areas near villages, such as Spong and Anlong Phe in the north or Kes and Doung.

6.0 PRIMATES

Prey Lang is home to five species of primates, all of which are considered as Threatened on the International Union for Conservation of Nature (IUCN) Red List.

Of the five species, one species, the long-tailed macaque, was recorded on cameras during the survey. The long-tailed macaque shifted from Vulnerable to Endangered in 2022 on the IUCN Red List of Threatened Species. The other species are either arboreal species or too cryptic to be recorded on cameras.

1 primate species recorded on camera trap

100% Threatened on the IUCN Red list:

1 Endangered

6.1 LONG-TAILED MACAQUE (*Macaca fascicularis* - ស្វាក្អាម)

6.1.1 DESCRIPTION

These medium-sized primates have a long tail, typically 40 to 65 cm, which is used for balance. Their hair varies in color from light brown to dark gray. Males are distinguished by moustaches as well as cheek whiskers around their faces, while females have beards and cheek whiskers. They have a cheek pouch that they use to store food while foraging, and they feed on a wide variety of food, depending on habitat. These primates are diurnal and highly social animals, living in groups ranging in size from around 20 to over 100 individuals.

Long tailed macaque

6.1.2 ACTIVITY PATTERN

In Prey Lang, long-tailed macaques are a diurnal species, with a peak of activity in the afternoon.

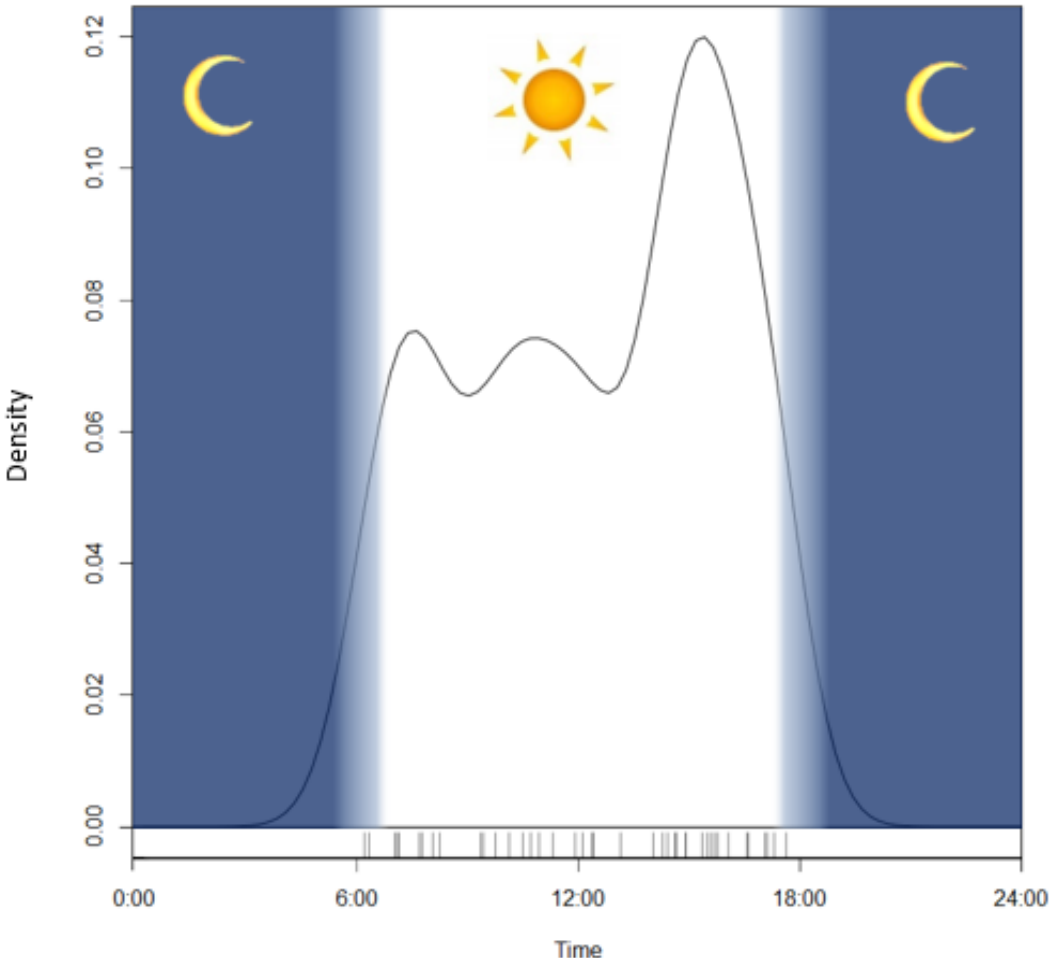

Figure 5: Activity Pattern of the Long-Tailed Macaque in Prey Lang

6.1.3 POPULATION

Although long-tailed macaques are widely distributed and are known to be tolerant to habitat changes, excessive hunting by humans throughout its range is a cause for concern. In 2022, they were listed as Endangered on the IUCN Red List, due to a high demand for the species in the national and international trade as well as deforestation and habitat fragmentation in Southeast Asia. This species is suspected to have undergone declines of at least 40% over the last three generations (approximately 40 years) (IUCN 2022).

In Prey Lang, long-tailed macaques are heavily persecuted. They are extremely valuable when caught live for the biomedical industry. This targeting trapping has extirpated this species in many areas throughout Cambodia and poses a significant risk to their persistence in Prey Lang.

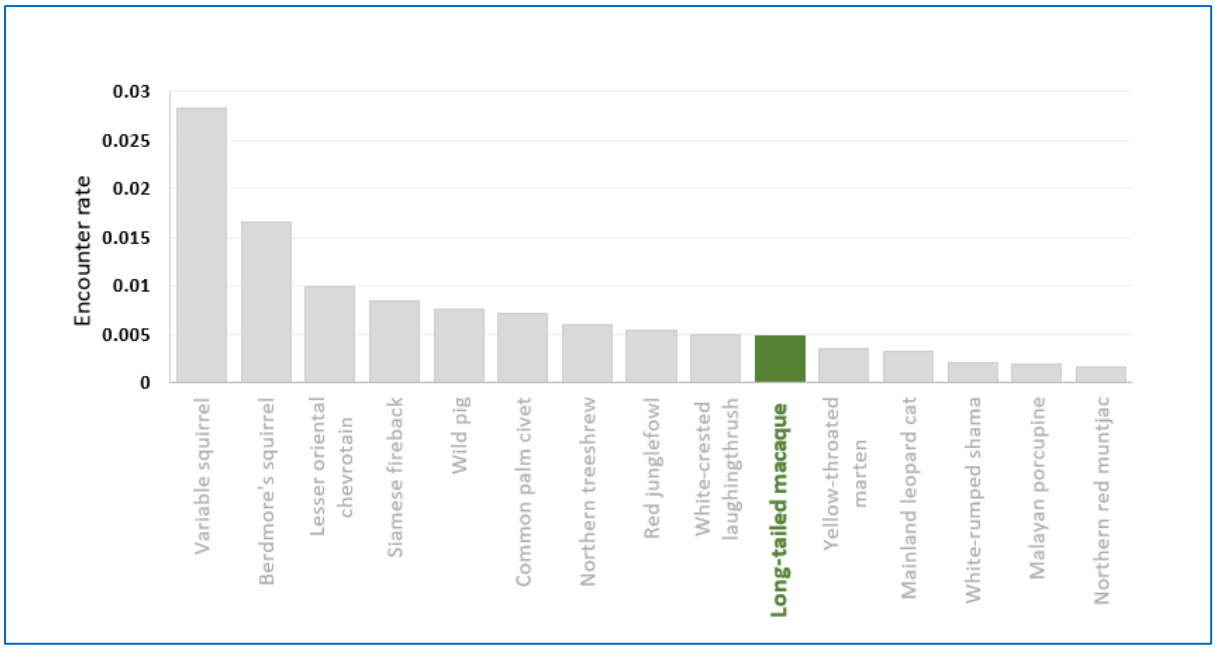

Figure 6: Encounter Rate (Number of Independent Records Divided by the Number of Camera Trap Days) of the Long-Tailed Macaque Compared to Other Wildlife Species

6.1.4 DISTRIBUTION

Long-tailed macaques are found throughout Southeast Asia. They are widely distributed and appear in a range of habitats, from primary lowland rainforests and disturbed, secondary rainforests to shrubland, mangroves, and even human settlements. Long-tailed macaques live most successfully in disturbed habitats and on the periphery of forests.

In Prey Lang, they are found in high densities near the villages of Kes and Doung, in dense and open forests. They are also seen along the river and at higher concentrations near Spong village in a more disturbed area, as well as in the south of the protected area in more open habitats next to roads. Local communities identify long-tailed macaques as one the most common species associated with human-wildlife conflict. They are one of the most common crop raiders.

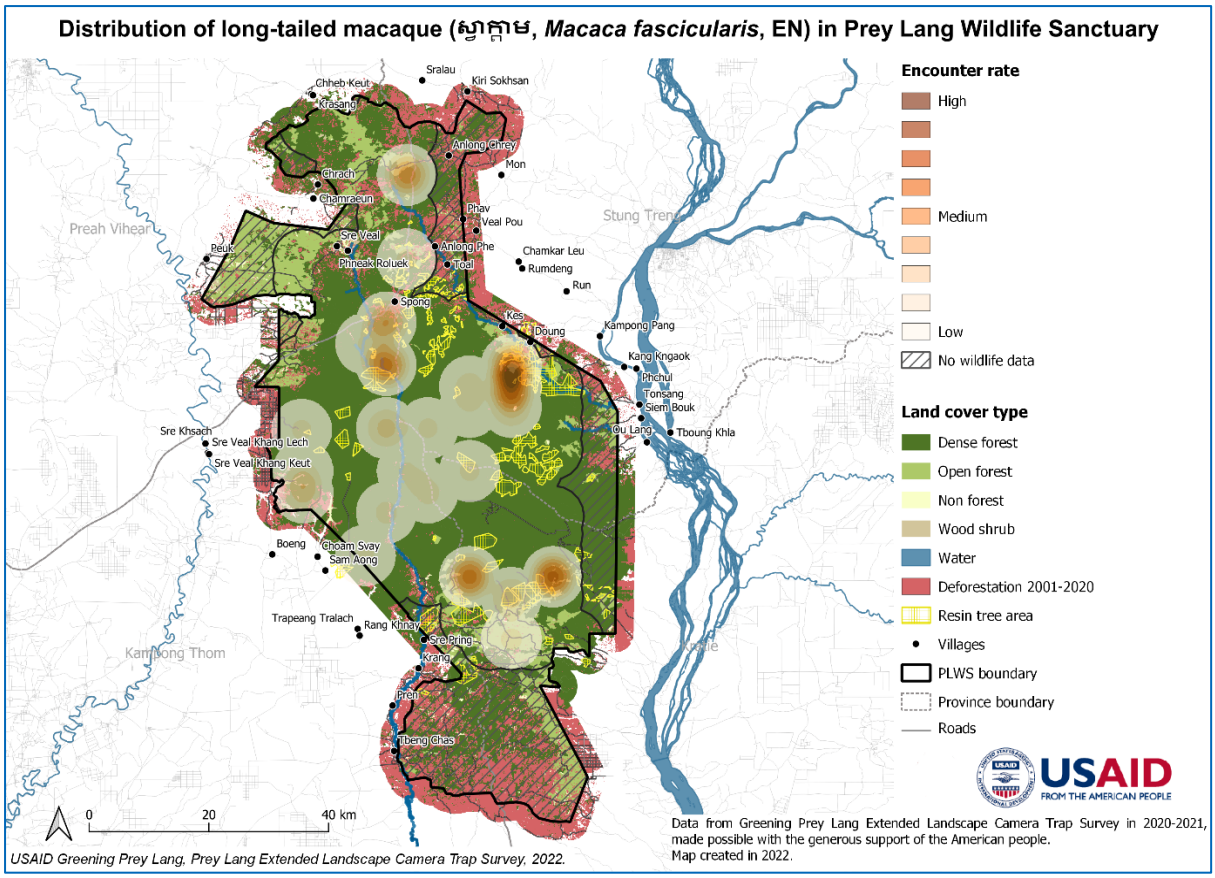

Figure 7: Distribution of Long-Tailed Macaque in Prey Lang Wildlife Sanctuary

7.0 UNGULATES

Prey Lang is home to six even-toed ungulates, and five were recorded on camera traps: lesser oriental chevrotain (*Tragulus kanchil*), wild pig (*Sus scrofa*), northern red muntjac (*Muntiacus vaginalis*), sambar (*Rusa unicolor*), and banteng (*Bos javanicus*).

Camera trapping is an efficient methodology to broadly target large-to-medium-sized terrestrial species, such as ungulates.

However, sambar and banteng appear at such low densities that it is not yet possible to produce spatial distribution estimates. In the long term, it might be possible to estimate spatial distribution for these species as another camera trap survey will yield additional records. The low camera trapping rates for these species suggest that only small, isolated populations remain.

5 ungulate species recorded on camera trap

40% of them Threatened on the IUCN Red list:

1 Endangered

- Banteng – ទន្សោង

1 Vulnerable

- Sambar – ប្រើស

1 Population estimate available

Sambar

7.1 LESSER ORIENTAL CHEVROTAIN (*Tragulus kanchil* - ក្តាន់ញ្ជេងតូច)

7.1.1 DESCRIPTION

This species is the smallest ungulate, its mature size being as little as 45 cm. The general color is reddish-brown, with a slender build, arched back, and pencil-thin legs. Lesser oriental chevrotains do not have horns or antlers, but males develop enlarged upper canine teeth that protrude from the mouth. This species is highly solitary. They are partly frugivorous and eat substantial quantities of shoots and young leaves.

Lesser oriental chevrotain

Lesser oriental chevrotain at dusk

7.1.2 ACTIVITY PATTERN

In Prey Lang, the lesser oriental chevrotain is a diurnal species with peaks of activity in the early morning and late afternoon, suggesting a degree of crepuscularity.

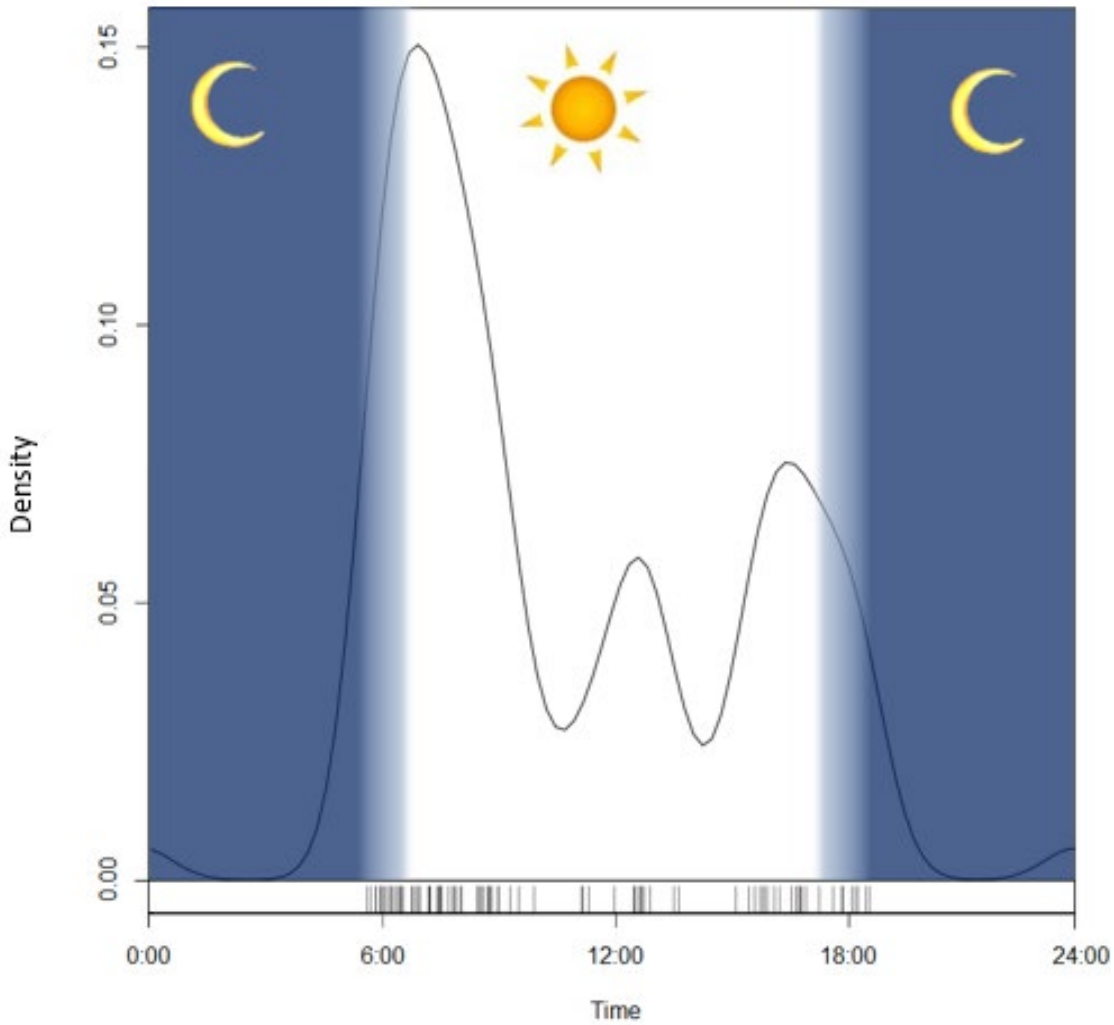

Figure 8: Activity Pattern of the Lesser Oriental Chevrotain in Prey Lang

7.1.3 POPULATION

The lesser oriental chevrotain populations are not well studied, but this species seems to be relatively widespread and common. No global population estimate is available.

During this camera trap survey, the lesser oriental chevrotain was the ungulate with the highest encounter rate. However, only a few cameras detected most of the observations. Due to the high variability in encounter rate, it was not possible to produce a reliable population estimate for this species.

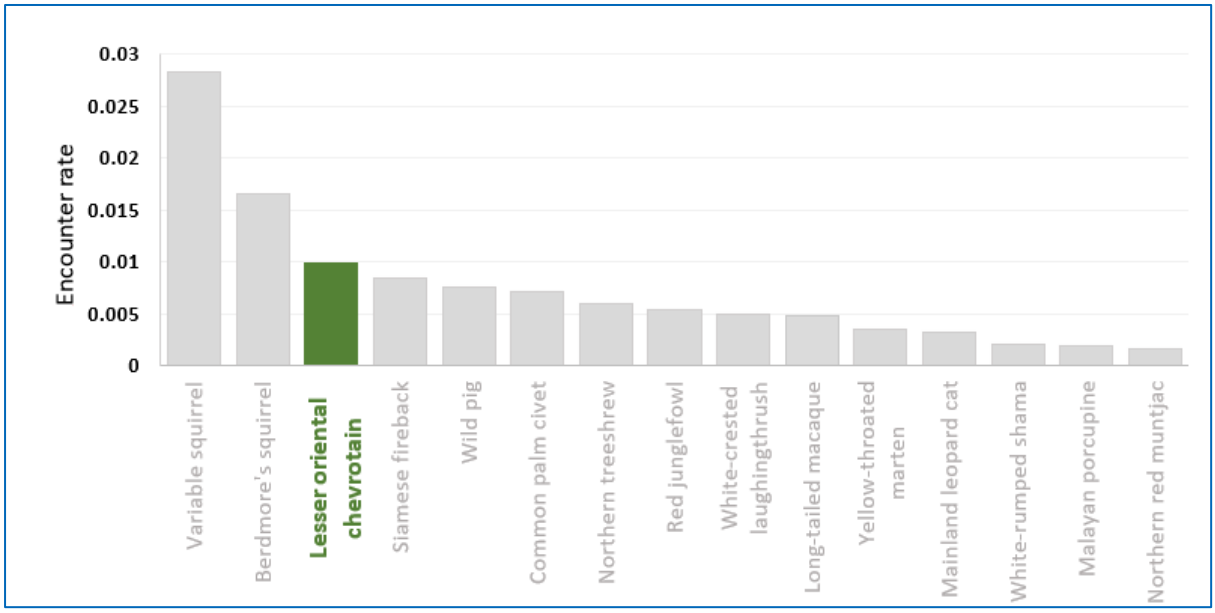

Figure 9: Encounter Rate (Number of Independent Records Divided by the Number of Camera Trap Days) of the Lesser Oriental Chevrotain Compared to Other Wildlife Species

7.1.4 DISTRIBUTION

The lesser chevrotain is widespread and appears to be at least locally common across its range. This species is commonly found in highly degraded forest and edge habitats. It appears to prefer immature forests with edge environments, clearings, and gaps in the forest canopy. Hunting and habitat loss occur at high levels almost all throughout this species' range, and it is also threatened by predation by feral dogs.

In Prey Lang, this species is found in high density in the central evergreen and semi-evergreen forests near roads. The population appears to be fragmented throughout the landscape.

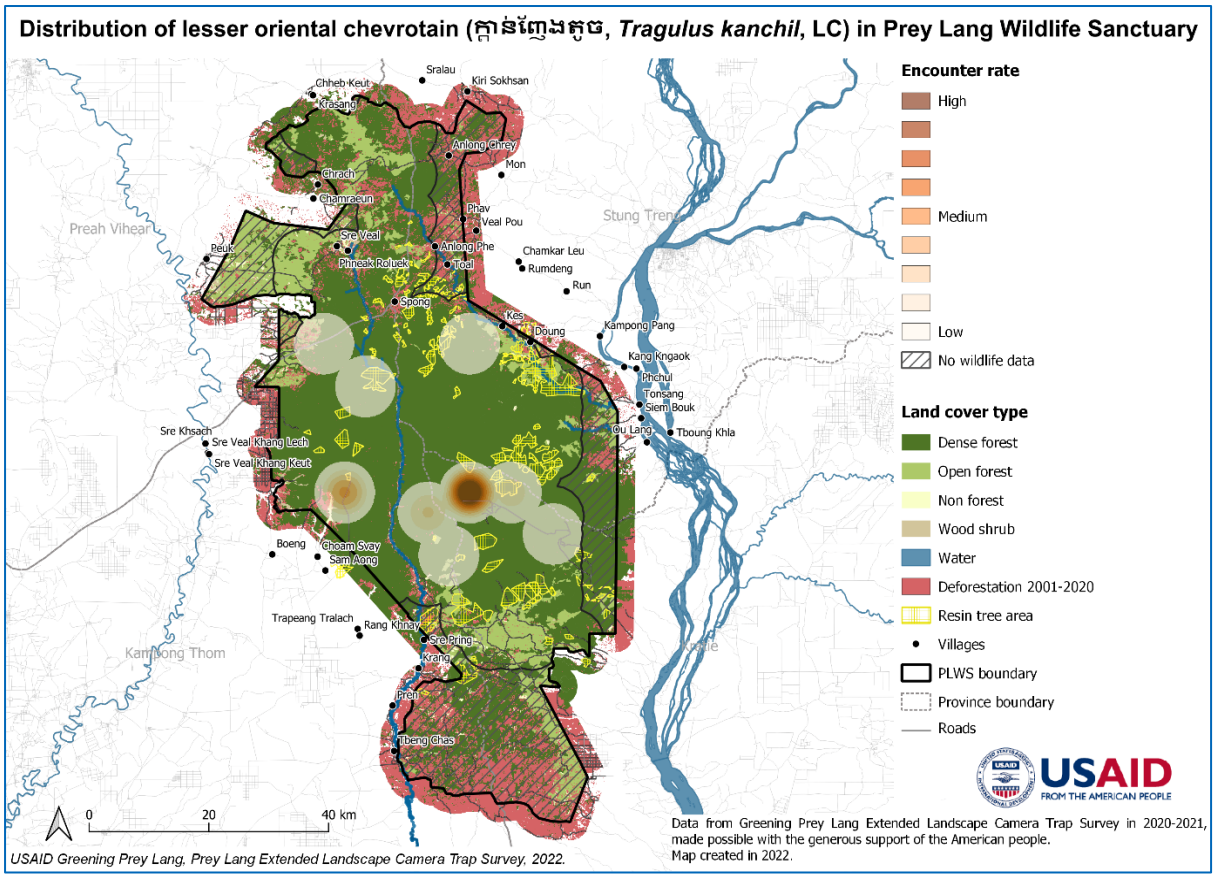

Figure 10: Distribution of Lesser Oriental Chevrotain in Prey Lang Wildlife Sanctuary

7.2 WILD PIG (*Sus scrofa* - ជ្រូកព្រៃ)

7.2.1 DESCRIPTION

Wild pigs are bulky, massively built species, with well-developed canines protruding from the mouth of adult males. They are gregarious, forming herds of between 6 to 20 individuals, though groups of over 100 individuals have been recorded. Wild pigs are highly versatile omnivores, with much of their diet consisting of food items dug from the ground. Fruits, seeds, roots, and tubers make up 90% of their diet.

Wild pig

7.2.2 ACTIVITY PATTERN

In Prey Lang, wild pigs show cathemeral activity patterns, with a peak of activity at night and in the afternoon.

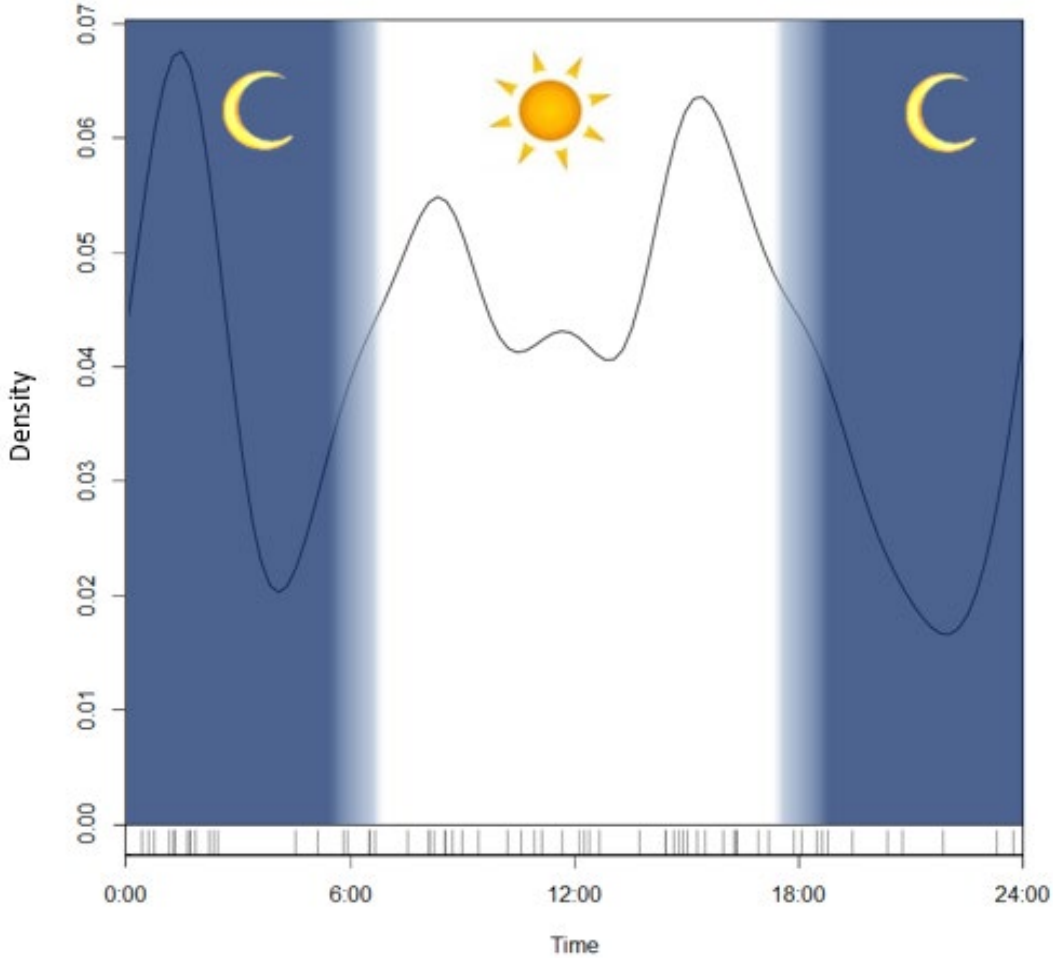

Figure 11: Activity Pattern of the Wild Pig in Prey Lang

Wild pig

7.2.3 POPULATION

This species is listed as Least Concern due to its wide range, abundance, tolerance to habitat disturbance, and presence in many protected areas. The global population is large and unknown but is likely to be stable.

In Prey Lang, wild pig was the ungulate with the second highest encounter rate. The population estimate for wild pig populations in Prey Lang is **226 individuals (95% CI 97–533)**, equivalent to a density of **0.09 individual per km² (95% CI 0.04–0.22).** Comparing these results with the most recent available surveys of protected areas in Cambodia shows that the population of wild pigs are significantly lower in Prey Lang. The Keo Seima Wildlife Sanctuary population estimate in 2020 is 1,162 individuals (95% CI 619–1,870), equivalent to a density of 0.62 (95% CI 0.33–0.99) (Griffin and Nuttall 2020). Population estimates in Srepok and Phnom Prich Wildlife Sanctuaries in 2020 are respectively 2,169 individuals (95% CI 1,452–3,240) and 1,848 individuals (95% CI 1,170–2,919), equivalent to 1.25 individuals per km² (95% CI 0.84–1.87) and 1.11 individuals per km² (95% CI 0.70–1.75) (Groenenberg, Crouthers, and Yoganand 2020). In Prey Lang, wild pigs are likely captured in snares, which are commonly set across the protected area.

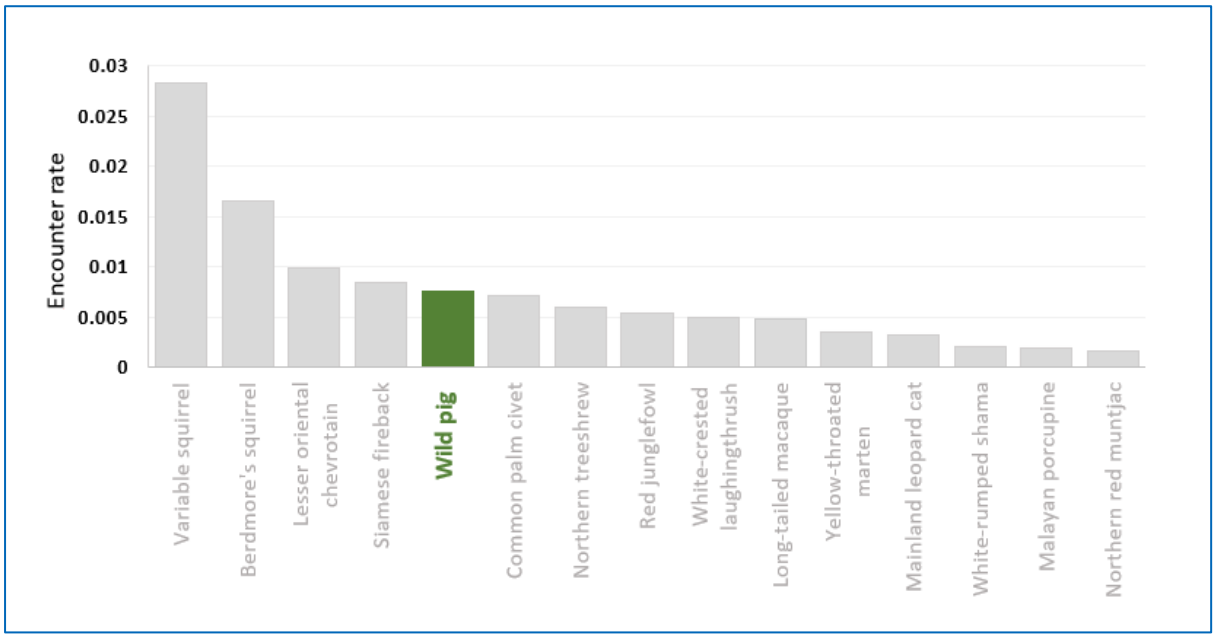

Figure 12: Encounter Rate (Number of Independent Records Divided by the Number of Camera Trap Days) of the Wild Pig Compared to Other Wildlife Species

7.2.4 DISTRIBUTION

This species has one of the widest geographic distributions of all terrestrial mammals and occupies a wide variety of temperate and tropical forests, from semi-deserts to tropical rainforests.

In Prey Lang, wild pigs occur at high concentrations in dense forests near Kes village and are widespread through the central evergreen and semi-evergreen forests. Community members identify wild pigs as a common source of wildlife conflict due to their frequent crop raiding.

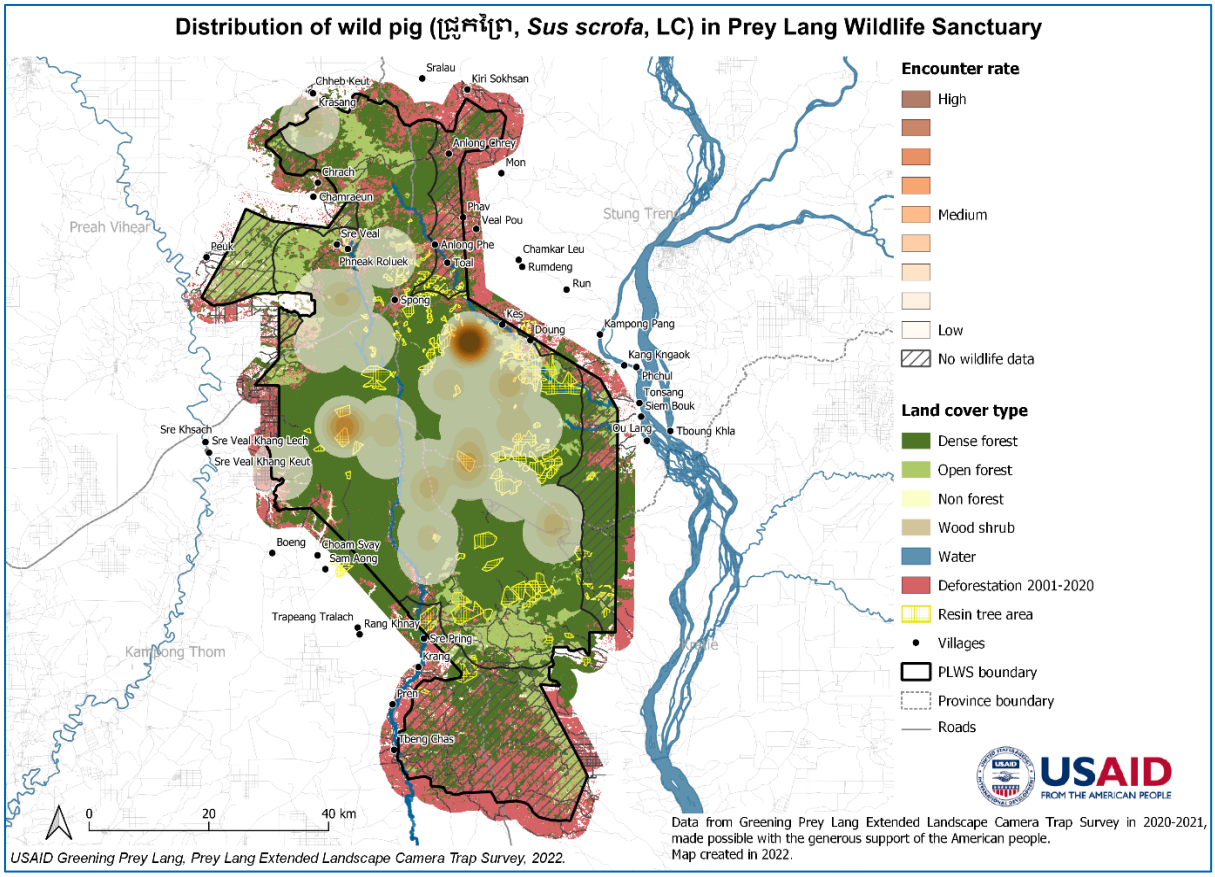

Figure 13: Distribution of Wild Pig in Prey Lang Wildlife Sanctuary

7.3 NORTHERN RED MUNTJAC (*Muntiacus vaginalis* - ญัญ)

7.3.1 DESCRIPTION

The northern red muntjac has a chestnut/red-colored coat, dark brownish-black facial markings, and small antlers. They eat grass, fruits, shoots, seeds, bird eggs, and small animals, and occasionally scavenge on animal carcasses. They are called "barking deer" due to the alarm call they make when a predator or other threat is nearby: the call sounds like the piercing bark of a small dog.

Northern red muntjac with dark facial markings

Male northern red muntjac with antlers

7.3.2 ACTIVITY PATTERN

In Prey Lang, northern red muntjacs show cathemeral activity patterns, although this species is most active in early morning.

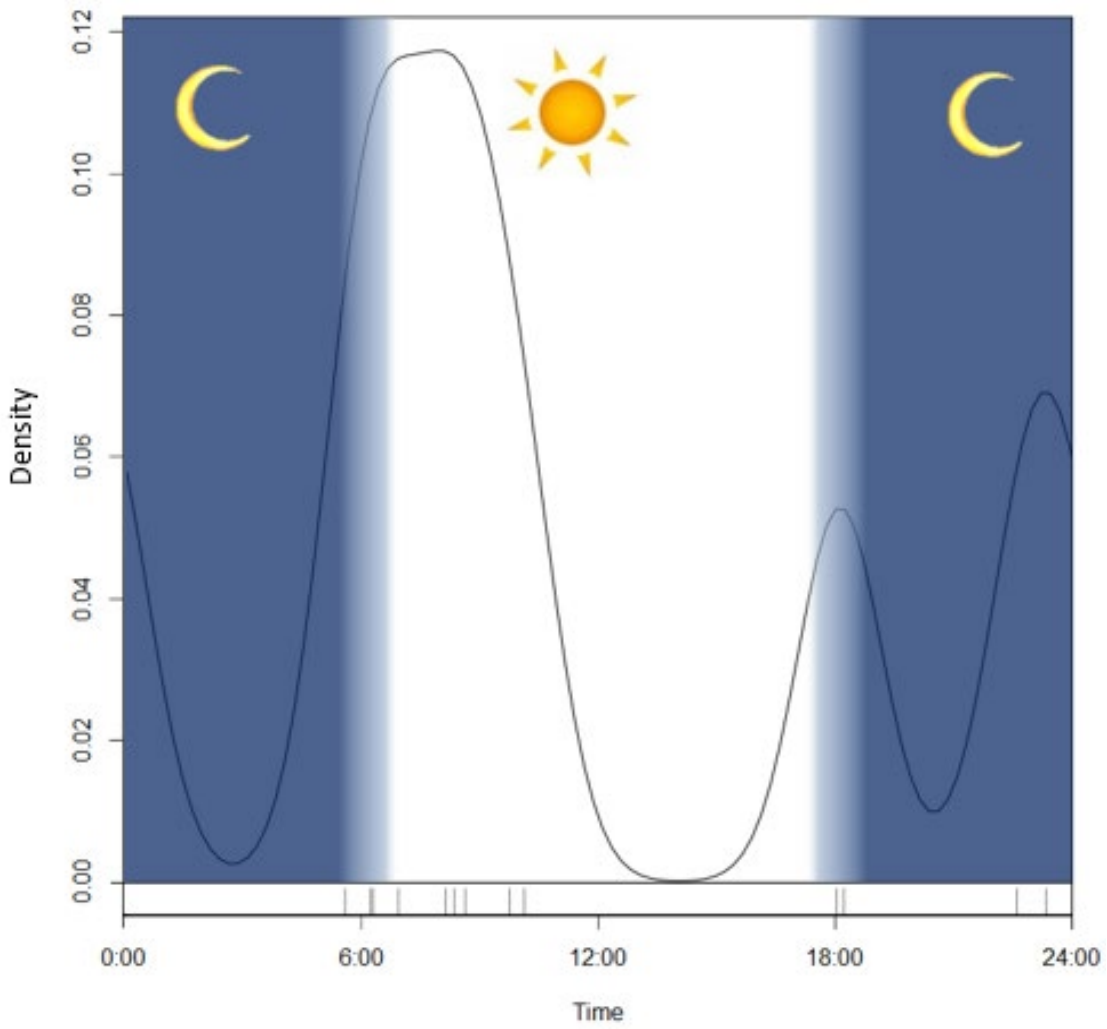

Figure 14: Activity Pattern of the Northern Red Muntjac in Prey Lang

7.3.3 POPULATION

This adaptable species remains locally common in most of its range, but populations are likely declining in Cambodia due to heavy trade-driven hunting (IUCN 2022).

In Prey Lang, the encounter rate for northern red muntjacs was low compared to other species. Snaring and hunting with dogs and homemade guns is quite common throughout the landscape, likely significantly impacting the local muntjac population. Northern red muntjac is probably among the most used and most desired wild meats in Southeast Asia and can be sold at a high price.

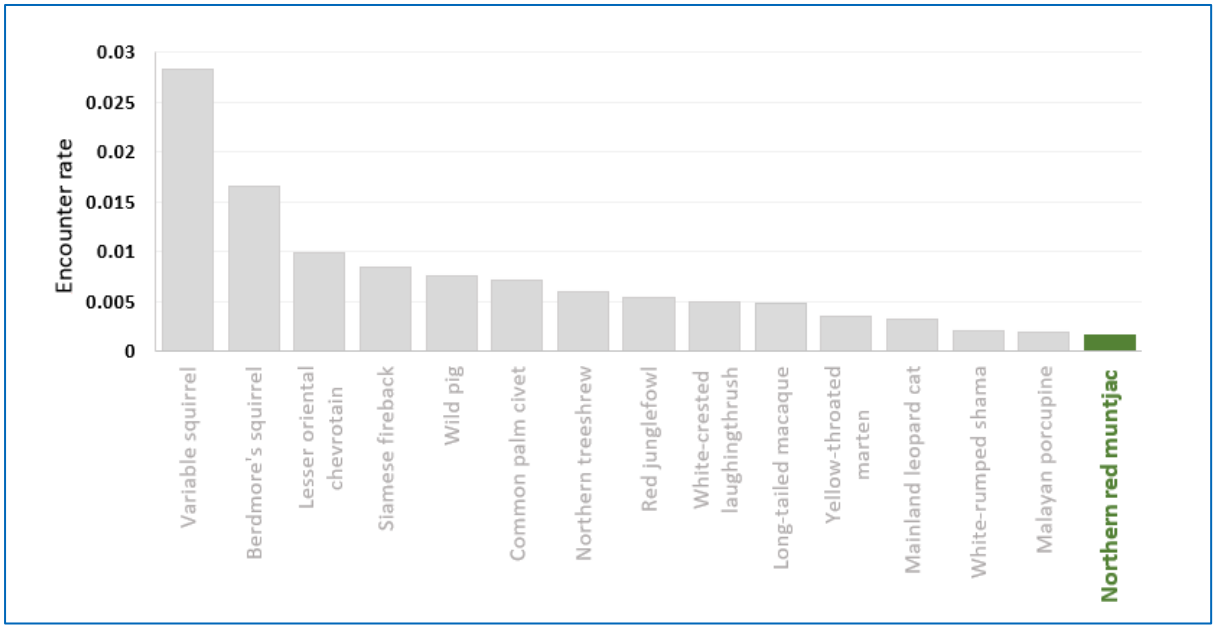

Figure 15: Encounter Rate (Number of Independent Records Divided by the Number of Camera Trap Days) of the Northern Red Muntjac Compared to Other Wildlife Species

7.3.4 DISTRIBUTION

The northern red muntjac inhabits a wide variety of forests and scrub. They are widespread in much of South and Southeast Asia, due to their resilience to habitat change and hunting.

However, in Prey Lang, the population of northern red muntjac appears restricted and fragmented throughout the landscape. They appear in highest density in the south of the protected area, in the middle of the road network in open forest habitats. They are also found in high densities in the north, in edge forest habitats, and deforested areas. This pattern of encounters may be reflective of a preference for more mixed-edge habitats rather than evergreen forests.

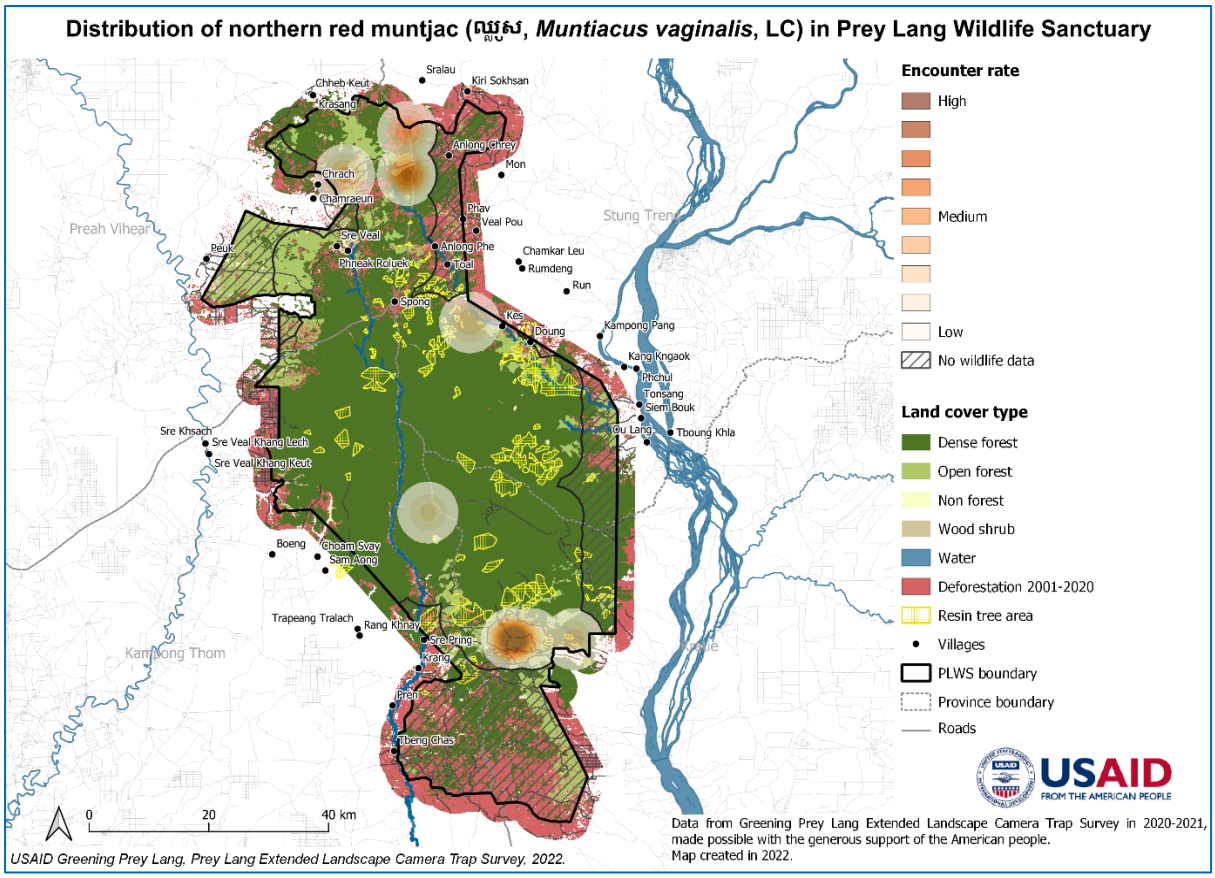

Figure 16: Distribution of Northern Red Muntjac in Prey Lang Wildlife Sanctuary

8.0 CARNIVORANS

Prey Lang is home to fifteen carnivorans, and seven were recorded on camera traps: common palm civet (*Paradoxurus hermaphroditus),* yellow-throated marten (*Martes flavigula*), mainland leopard cat (*Prionailurus bengalensis*), sun bear (*Helarctos malayanus),* Asiatic black bear (*Ursus thibetanus),* small Indian civet (*Viverricula indica*), and binturong (*Arctictis binturong).*

However, the sun bear, Asiatic black bear, binturong, and small Indian civet occur at such low densities that it is not yet possible to produce spatial distribution estimates. In the long term, it might be possible to estimate spatial distribution for these species as another camera trap survey will yield additional records. However, it might also be possible that this methodology is not adapted for these species and thus requires a more targeted camera trap survey with individual recognition.

No population estimates are available for carnivoran species.

7 carnivoran species recorded on camera trap

43% of them Threatened on the IUCN Red list:

1 Endangered

- Binturong – សំពោចភ្នំ

2 Vulnerable

- Sun bear – ខ្លាឃ្មុំតូច
- Asiatic black bear – ខ្លាឃ្មុំធំ

Asiatic black bear

8.1 COMMON PALM CIVET (*Paradoxurus hermaphroditus* - សំពោចក្រអូប)

8.1.1 DESCRIPTION

Like racoons, common palm civets' faces are banded and have a white patch of fur below and above the eyes and on each side of the nose. They can be recognized by the dark stripes down their back and the three rows of black spots freckled on each side of their body and covering their legs. Unlike other civets, the common palm civet tail does not have black rings. This species is both terrestrial and arboreal and leads a solitary life, except for brief periods during mating. It is an omnivore species, feeding foremost on fruits.

8.1.2 ACTIVITY PATTERN

In Prey Lang, the camera trap survey confirmed that the common palm civet is an exclusively nocturnal species, with a peak of activity in the late evening.

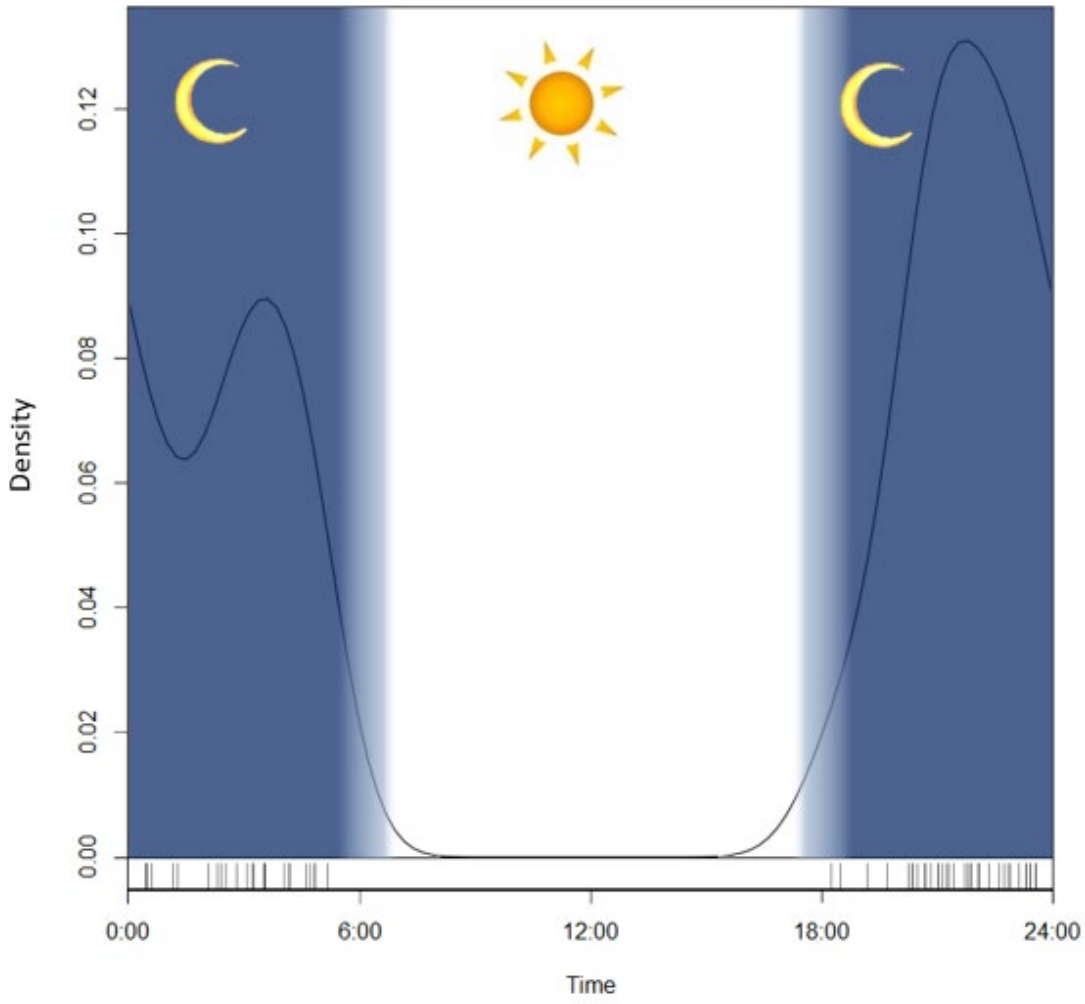

Figure 17: Activity Pattern of the Common Palm Civet in Prey Lang

8.1.3 POPULATION

The common palm civet is listed as Least Concern because it has a wide distribution, consists of large populations, uses a broad range of habitats, and is tolerant of extensive habitat degradation and change. However, with the ongoing hunting pressure, particularly in northern Southeast Asia, the global population is likely in decline.

During this camera trap survey, the common palm civet was the carnivoran species with the highest encounter rate. Civets are targeted for live capture throughout Prey Lang, most commonly for the civet coffee industry. Non-targeted snaring is also common throughout Prey Lang and likely also impacts the common palm civet population.

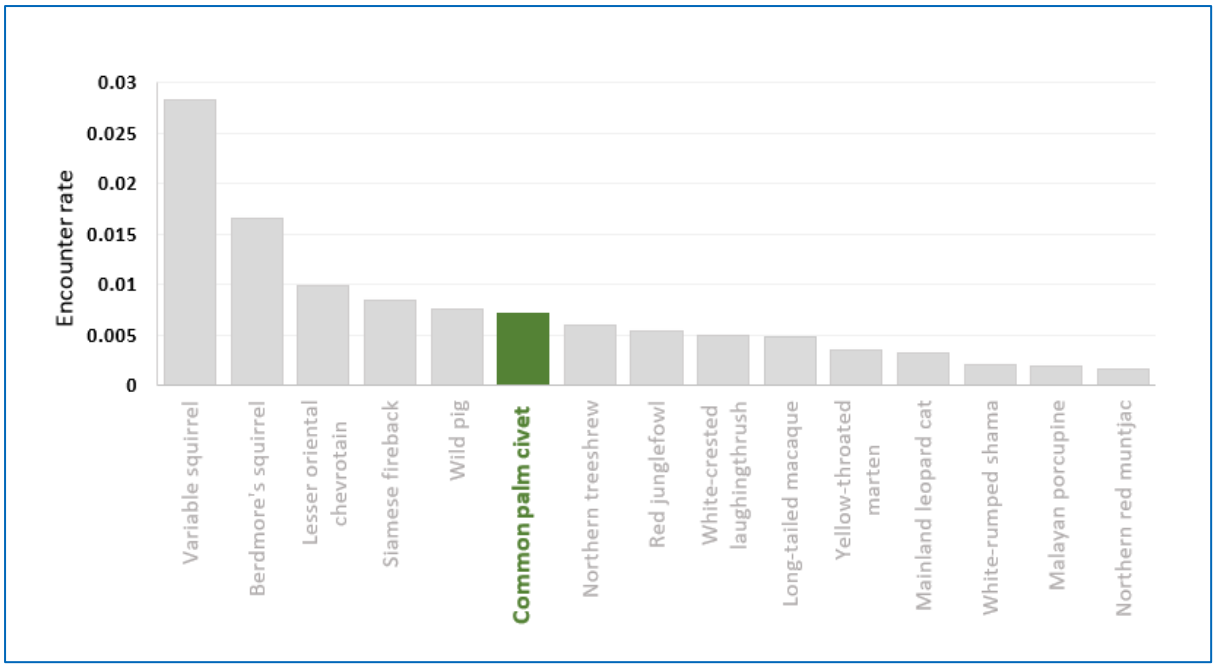

Figure 18: Encounter Rate (Number of Independent Records Divided by the Number of Camera Trap Days) of the Common Palm Civet Compared to Other Wildlife Species

8.1.4 DISTRIBUTION

The common palm civet has a wide distribution in South and Southeast Asia. This species is a highly adaptive animal and uses a wide range of habitats, including evergreen and deciduous forests (primary and secondary) and agricultural areas. It is adapted for forest living, yet it also tolerates living in areas near people.

This species occurs at high density on the east side of the Prey Lang in dense forest habitat next to roads.

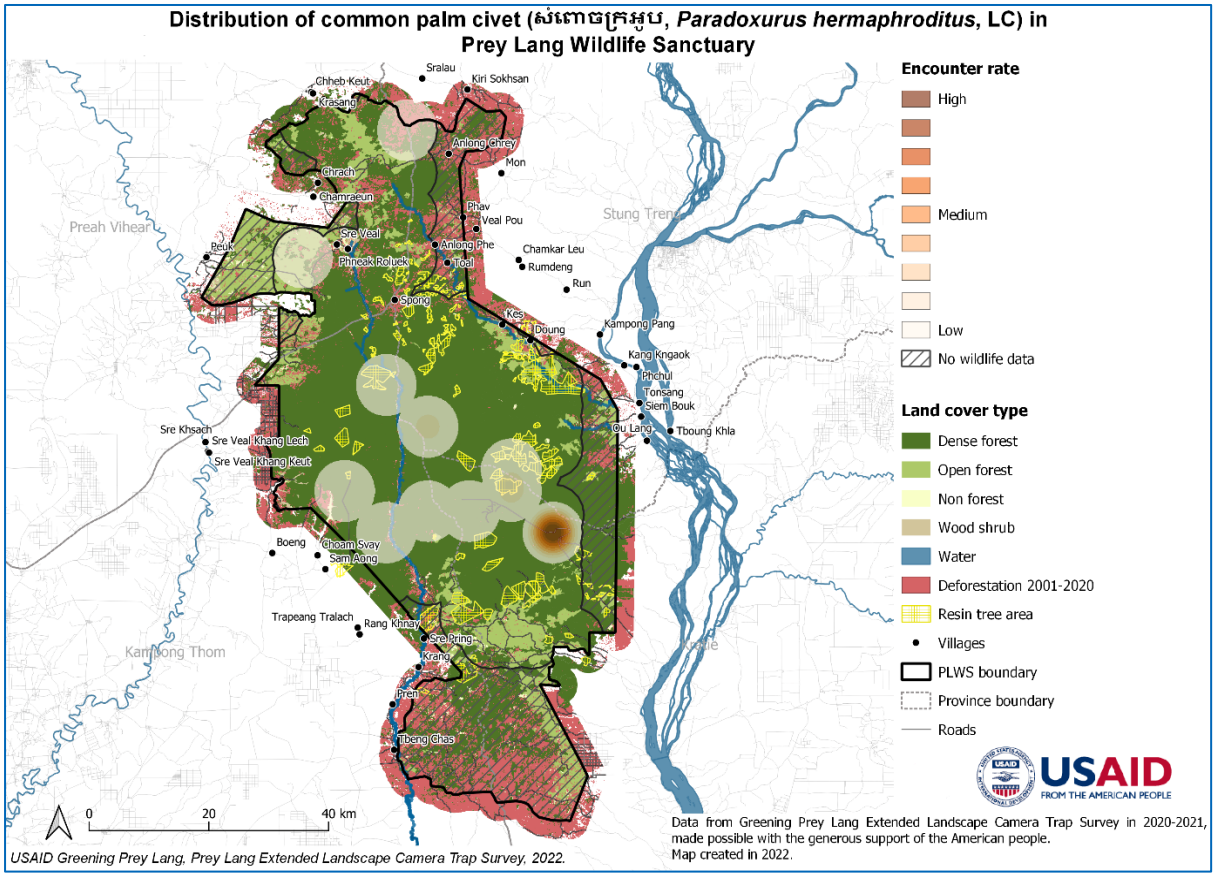

Figure 19: Distribution of Common Palm Civet in Prey Lang Wildlife Sanctuary

8.2 YELLOW-THROATED MARTEN (*Martes flavigula* - *សំពោចកសៀង*)

8.2.1 DESCRIPTION

The yellow-throated marten is the largest marten in the Old World, with the tail making up more than half its length. It is a robust and flexible animal with an elongated thorax and a long neck. The fur color of this species ranges from dark brown to a yellow brown with a distinctive creamy yellow throat. The chin and lower lips are pure white. It is an omnivore, whose sources of food range from fruit and nectar to small deer.

Yellow throated marten

8.2.2 ACTIVITY PATTERN

In Prey Lang, the yellow-throated marten is a strongly diurnal species, with a peak of activity in the morning.

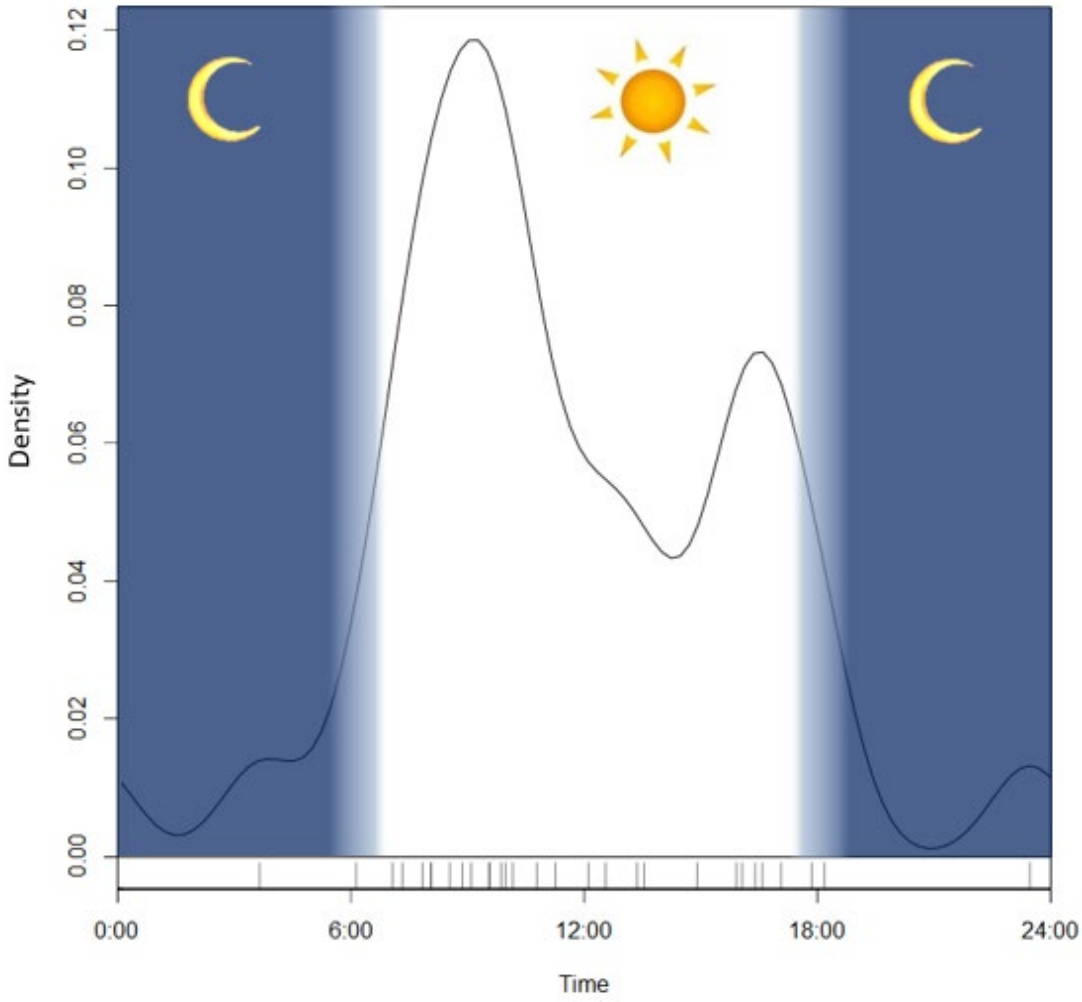

Figure 20: Activity Pattern of the Yellow-Throated Marten in Prey Lang

8.2.3 POPULATION

The yellow-throated marten is listed as Least Concern due to its wide geographic and habitat distribution, occurrence in several protected areas, presence in heavily degraded areas, and lack of identified major threats. However, no overall population estimate is available.

Hunting in Prey Lang using snares, dogs, and homemade guns likely impacts the yellow-throated marten population; while they may not be specifically targeted, they are likely caught opportunistically.

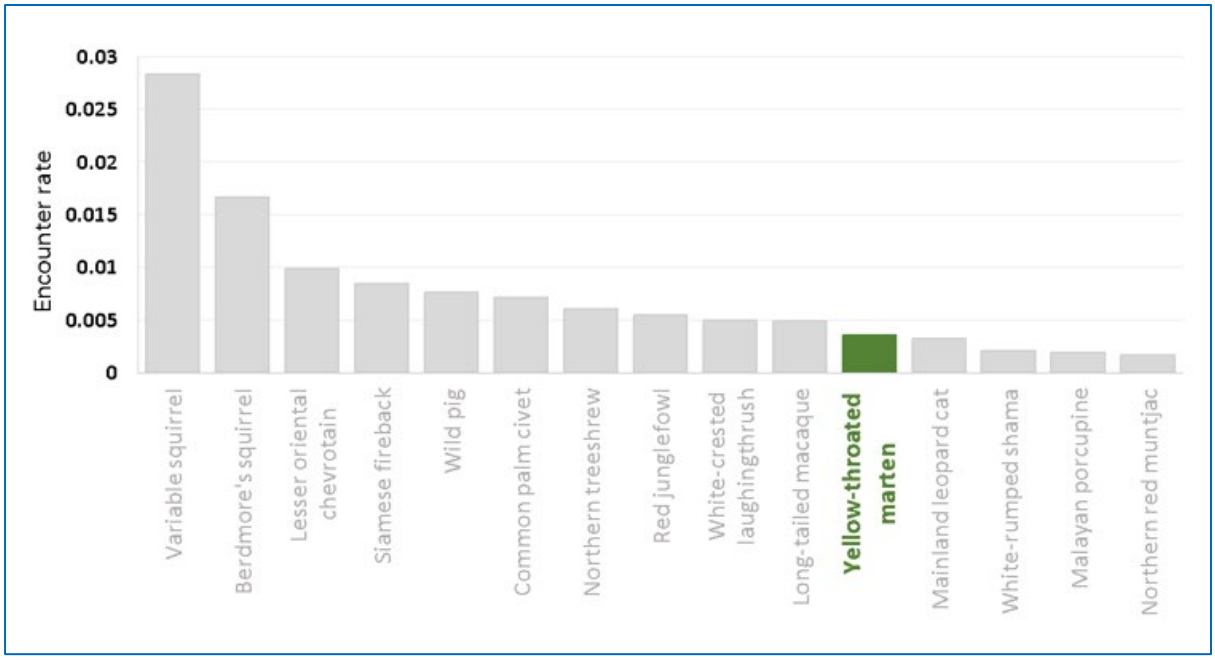

Figure 21: Encounter Rate (Number of Independent Records Divided by the Number of Camera Trap Days) of the Yellow-Throated Marten Compared to Other Wildlife Species

8.2.4 DISTRIBUTION

The yellow-throated marten can be found throughout mainland Southeast Asia, in Cambodia, Myanmar, Thailand, Laos, Cambodia, Vietnam, and Peninsular Malaysia. In Southeast Asia, this species appears in primary and secondary forests but can also adapt to heavily degraded habitats and live near humans.

In Prey Lang, yellow-throated martens are widespread throughout the landscape and seen in a variety of habitats. They are found in higher densities along the river in the central evergreen and semi-evergreen forests, as well as in disturbed areas near the west border of the protected area.

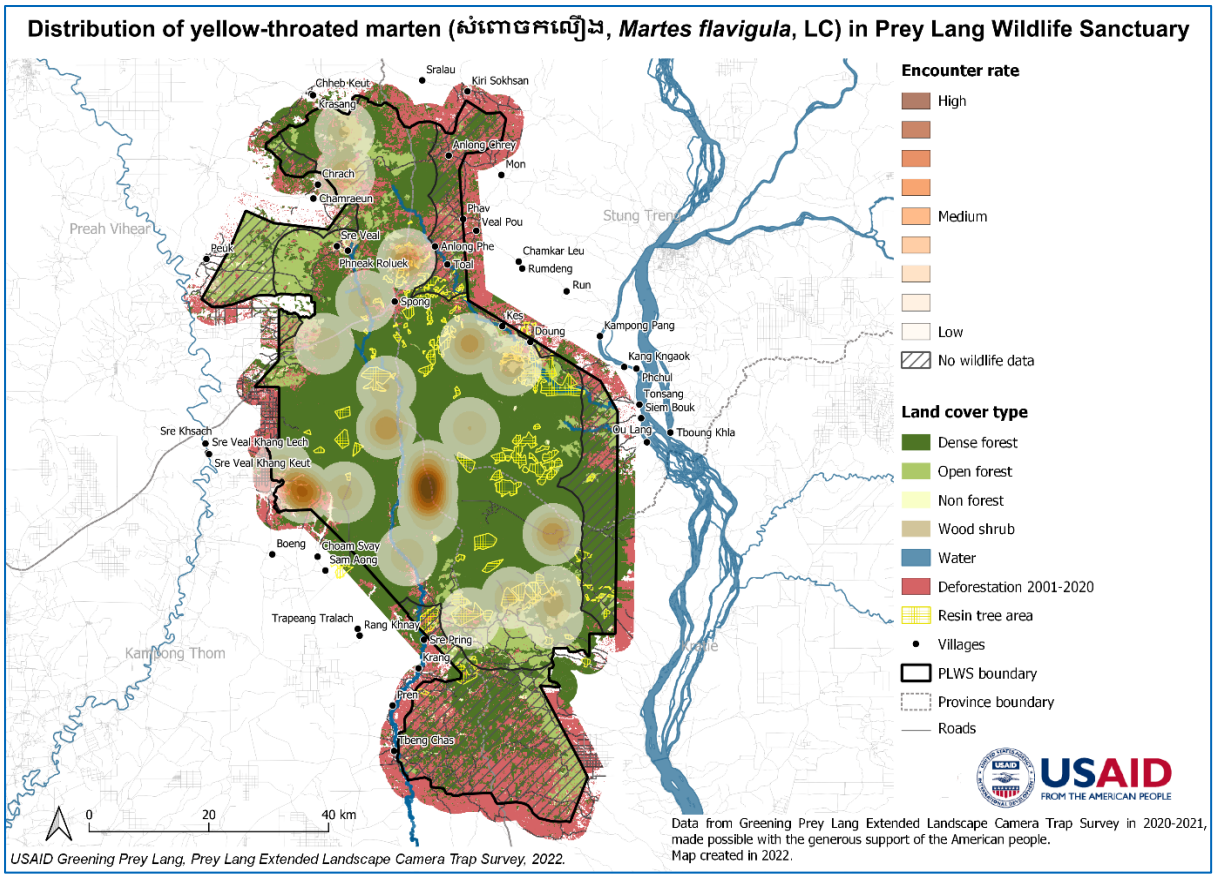

Figure 22: Distribution of Yellow-Throated Marten in Prey Lang Wildlife Sanctuary

8.3 MAINLAND LEOPARD CAT (*Prionailurus bengalensis* - ឆ្មាដាវ)

8.3.1 DESCRIPTION

The mainland leopard cat is among the smallest of Southeast Asia's wild cats. It is about the size of a domestic cat, but slenderer with longer legs. Its head is marked with two prominent dark stripes as well as a short and narrow white muzzle. Body and limbs are marked with black spots of varying size and color, and along its back are two or four rows of elongated spots. They are carnivorous, feeding on small mammals, lizards, amphibians, birds, and insects.

Mainland leopard cat

8.3.2 ACTIVITY PATTERN

The mainland leopard cat is nocturnal and most active at night, but in Prey Lang, this species is sometimes active during daytime and at dusk as well.

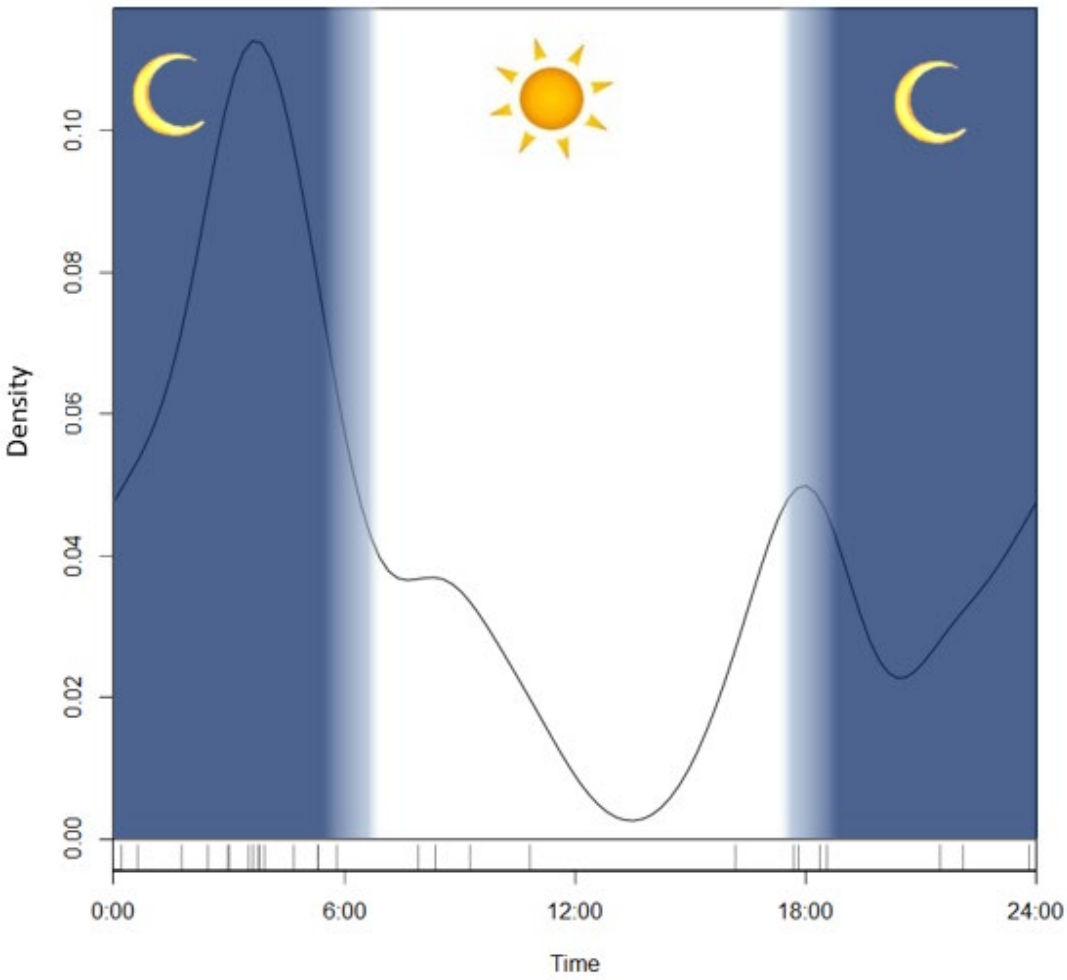

Figure 23: Activity Pattern of the Mainland Leopard Cat in Prey Lang

Mainland leopard cat at night

8.3.3 POPULATION

The mainland leopard cat is widely distributed and appears to be common across its large geographic range. It seems to tolerate human-modified environments to a better degree than other sympatric cat species. However, little is known concerning the species' global population size and status.

Like most terrestrial animals in Prey Lang, leopard cats are likely impacted by the widespread use of snares for capturing wildlife.

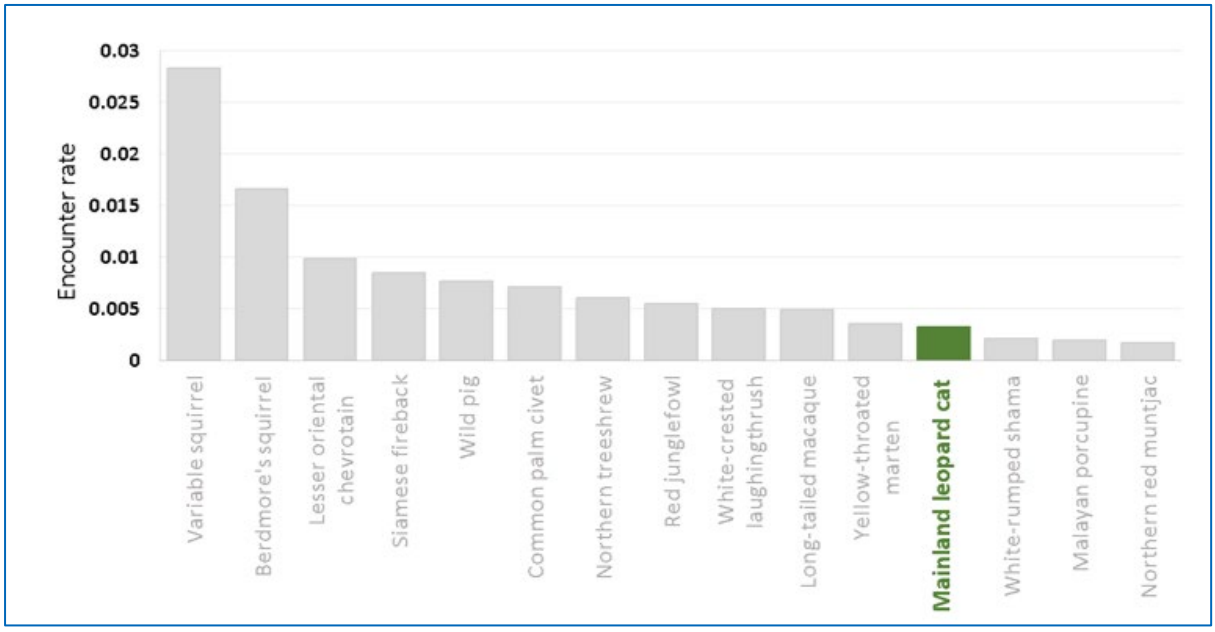

Figure 24: Encounter Rate (Number of Independent Records Divided by the Number of Camera Trap Days) of the Mainland Leopard Cat Compared to Other Wildlife Species

8.3.4 DISTRIBUTION

Mainland leopard cats are one of the most widely distributed cat species in the world, with its distribution ranging from the Russian Far East in the north to Singapore in the south. This species is highly adaptable, living in a wide range of habitats, such as various types of primary forests; secondary habitats, including cultivated areas; and plantations, including palm-oil.

However, in Prey Lang, the population appears to be restricted and can be found in the highest density in the east part of the protected area along the road, nearby the Mekong River. This species also appears at low densities in edge forest habitats next to the west border of Prey Lang.

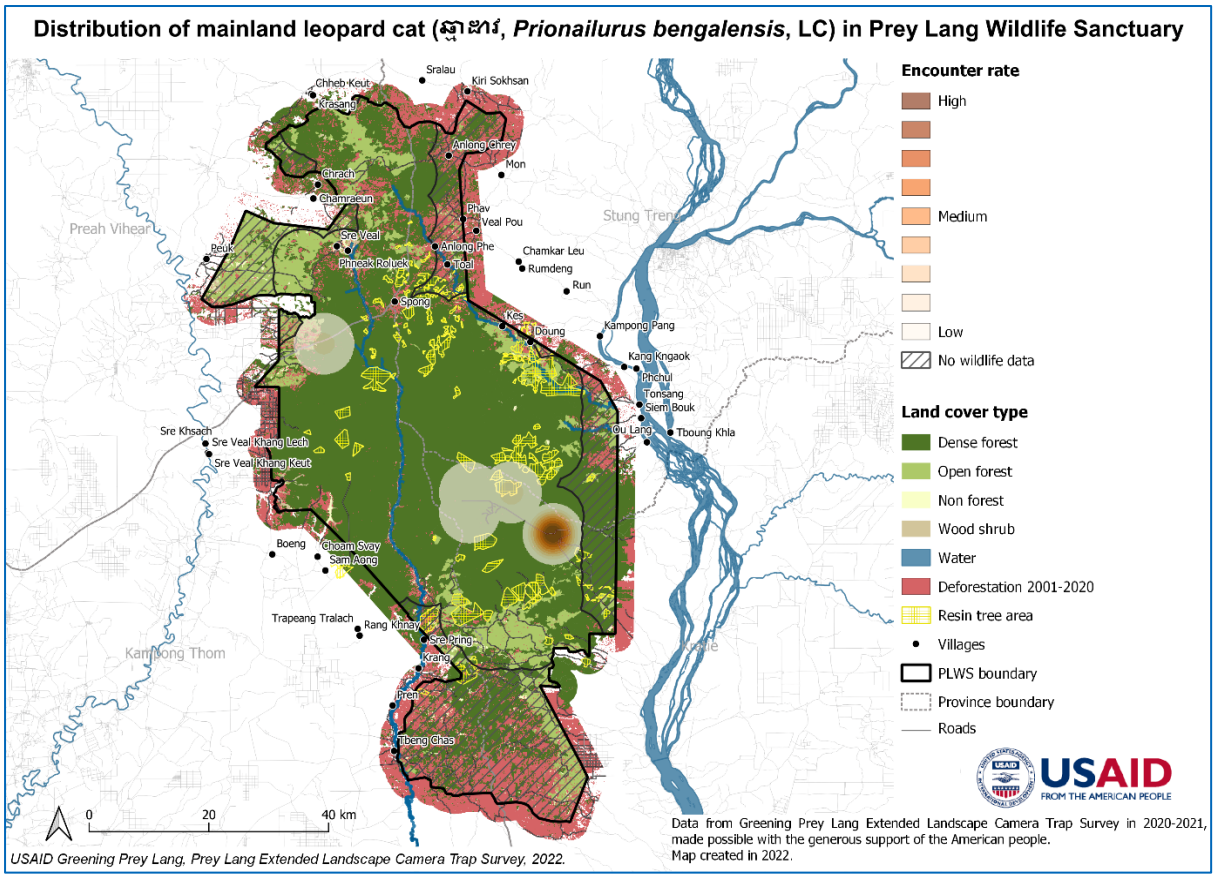

Figure 25: Distribution of Mainland Leopard Cat in Prey Lang Wildlife Sanctuary

9.0 RODENTS

Prey Lang is home to seven rodent species, and five were recorded on camera traps: variable squirrel (*Callosciurus finlaysonii*), Berdmore's squirrel (*Menetes berdmorei*), Cambodian striped squirrel (*Tamiops rodolphii*), northern treeshrew (*Tupaia belangeri*), and Malayan porcupine (*Hystrix brachyura*).

However, the Cambodian striped squirrel occurs at such low density that it is not possible to produce spatial distribution estimates.

5 rodent species recorded on camera trap

None of them Threatened on the IUCN Red list

2 Population estimate available

Variable squirrel

Cambodian striped squirrel

9.1 VARIABLE SQUIRREL (*Callosciurus finlaysonii* - ក្រុមុកពណ៌)

9.1.1 DESCRIPTION

This squirrel is referred to as variable squirrel due to the variability of the coat color. The subspecies found in Cambodia is recognizable by its overall rufous fur with a light white band on the tail. This is a canopy-dweller species, feeding on a variety of seeds and fruits.

Variable squirrel

9.1.2 ACTIVITY PATTERN

In Prey Lang, the variable squirrel is a diurnal species, with peaks of activity early in the morning and late afternoon.

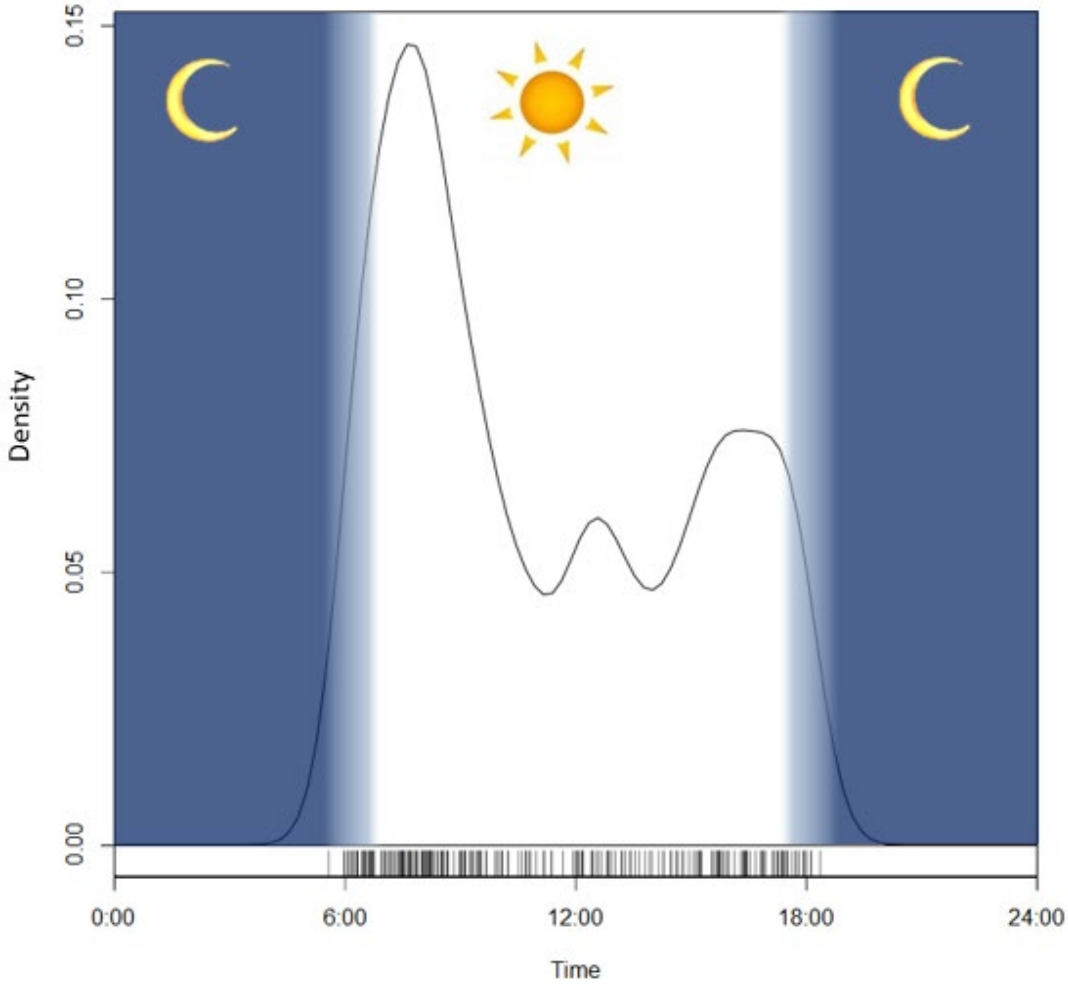

Figure 26: Activity Pattern of the Variable Squirrel in Prey Lang

9.1.3 POPULATION

The variable squirrel is listed as Least Concern because of its wide distribution and large population. This species is very tolerant of degradation and fragmentation. During this camera trap survey, the variable squirrel had the highest encounter rate among other wildlife species.

The population estimate for variable squirrel populations in Prey Lang is **1,276 individuals (95% CI 823–2,010)**, equivalent to a density of **0.53 individual per km² (95% CI 0.34–0.83).** The population estimate for this species is the first ever obtained in Southeast Asia.

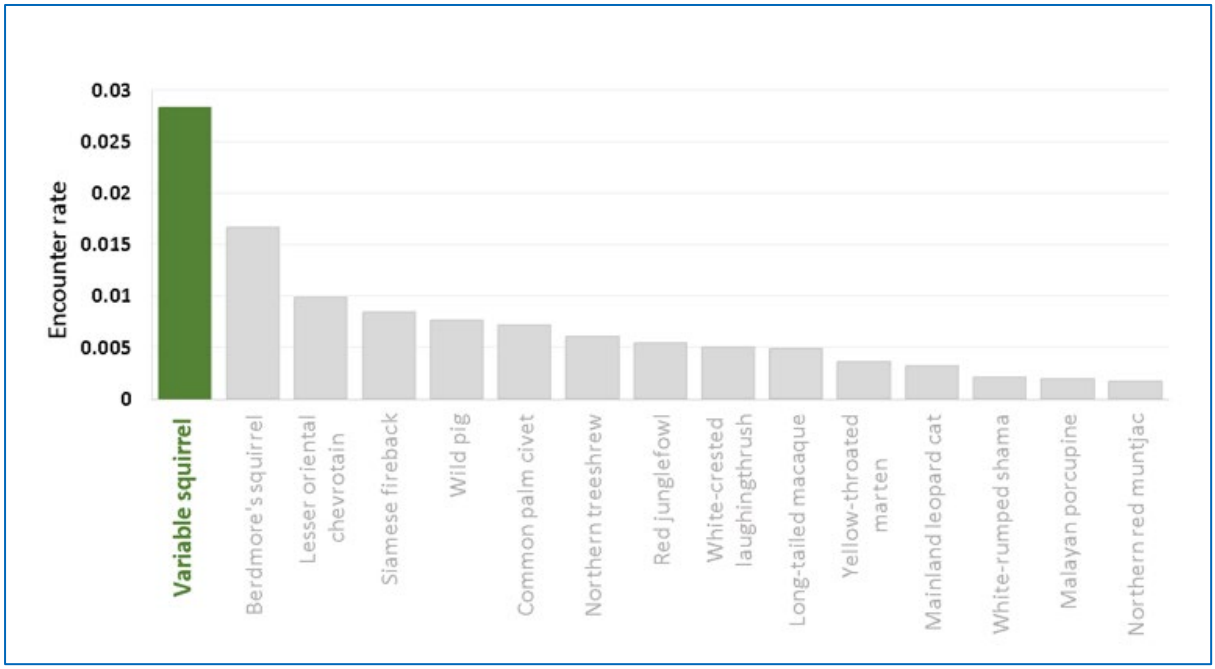

Figure 27: Encounter Rate (Number of Independent Records Divided by the Number of Camera Trap Days) of the Variable Squirrel Compared to Other Wildlife Species

9.1.4 DISTRIBUTION

The variable squirrel occurs in Cambodia, Myanmar, Thailand, Laos, and Vietnam. It is an arboreal species found in diverse habitats from primary and secondary forests to open woodland and plantations.

In Prey Lang, variable squirrels are widespread throughout the landscape and live in all types of habitats. This species appears very tolerant to habitat modifications.

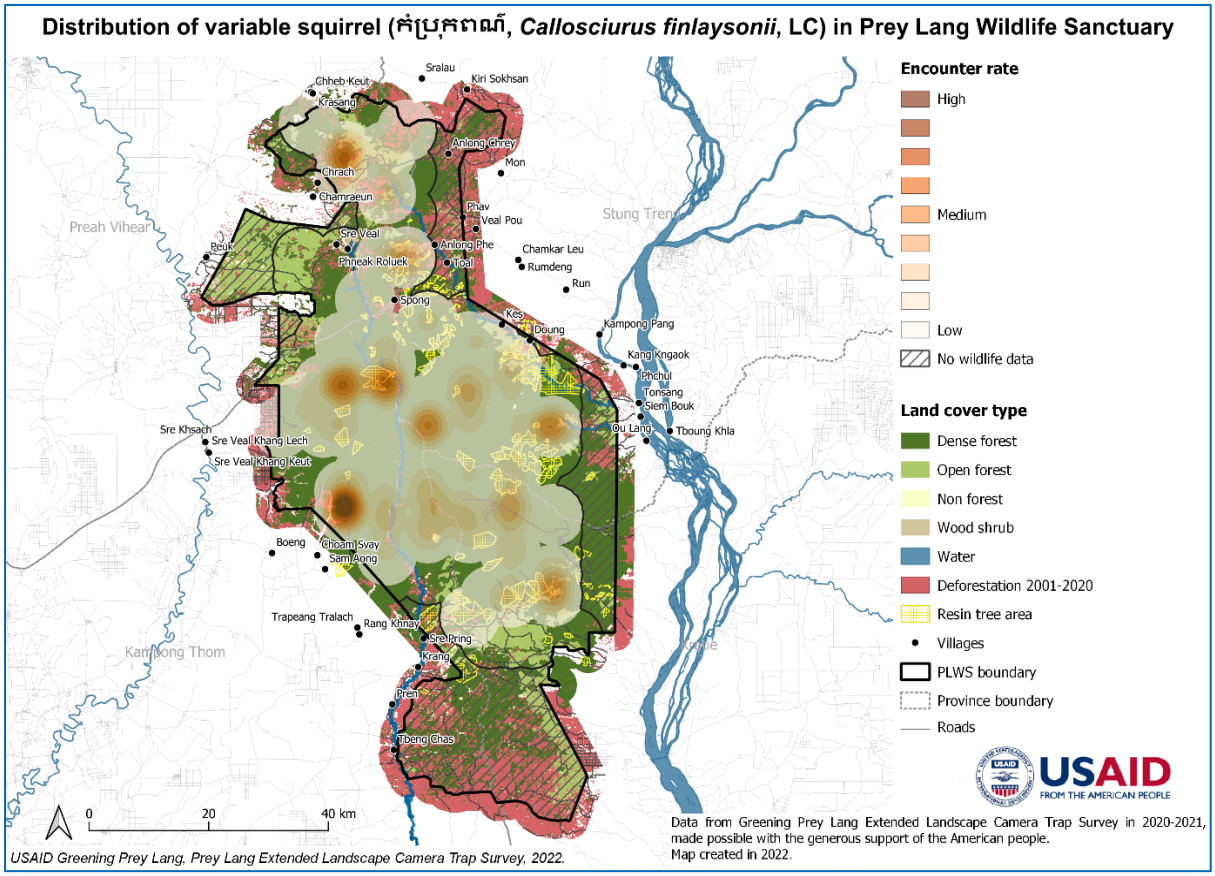

Figure 28: Distribution of Variable Squirrel in Prey Lang Wildlife Sanctuary

9.2 BERDMORE'S SQUIRREL (*Menetes berdmorei* - ក្រាន)

9.2.1 DESCRIPTION

The Berdmore's squirrel is a squirrel with characteristic stripes on each side of the body, one beige stripe with a black stripe below it. As a ground squirrel, it spends most of its time foraging on the ground in forests and along the forest edge. This species is omnivorous and has a diet rich in fungi, nuts, fruits, and seeds.

Berdmore's squirrel

Berdmore's squirrel at dusk

9.2.2 ACTIVITY PATTERN

In Prey Lang, the Berdmore's squirrel can be described as a crepuscular species, being most active at dawn and dusk.

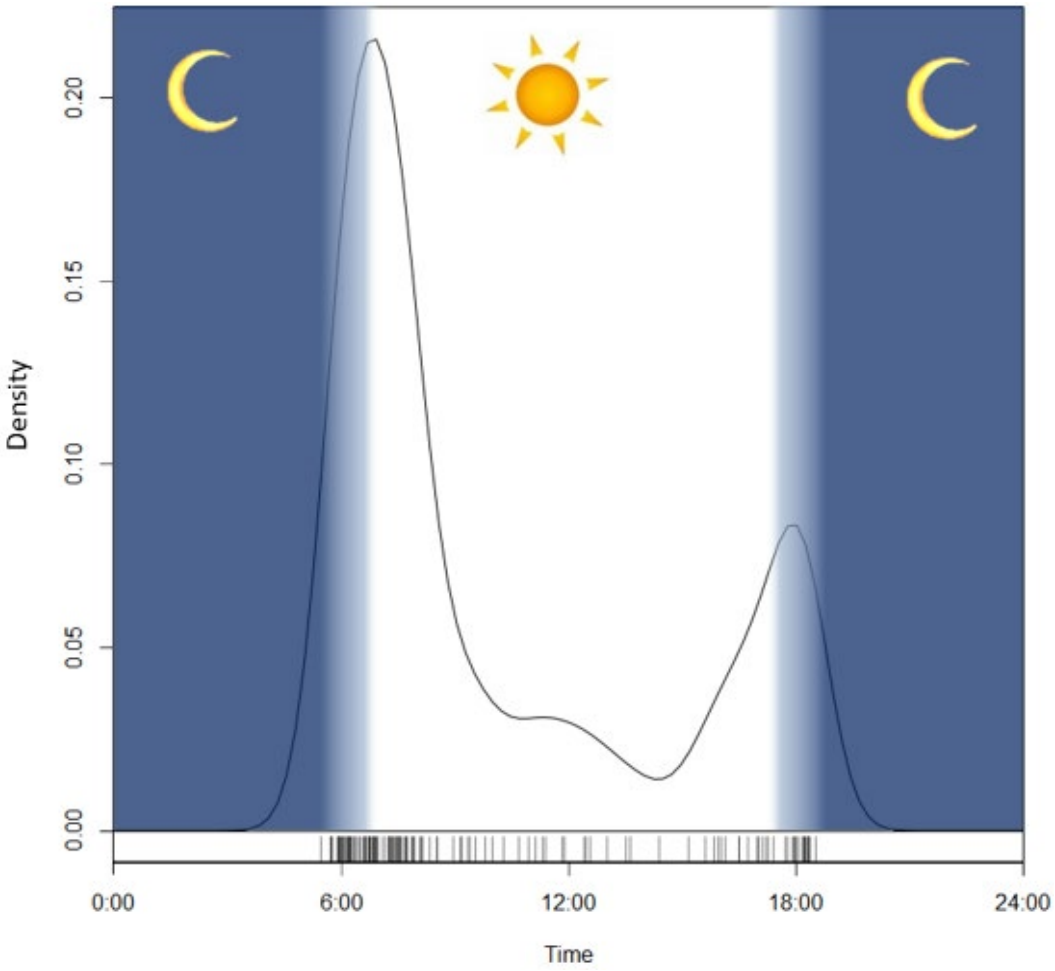

Figure 29: Activity Pattern of the Berdmore's Squirrel in Prey Lang

9.2.3 POPULATION

The Berdmore's squirrel is a widespread species that is abundant in suitable habitats. It can also tolerate highly disturbed habitats. During the camera trap survey, this species had the second highest encounter rate among other wildlife species.

The population estimate for Berdmore's squirrel populations in Prey Lang is **553 individuals (95% CI 218–1,090)**, equivalent to a density of **0.23 individual per km² (95% CI 0.09–0.45).** The population estimate for this species is the first ever obtained in Southeast Asia.

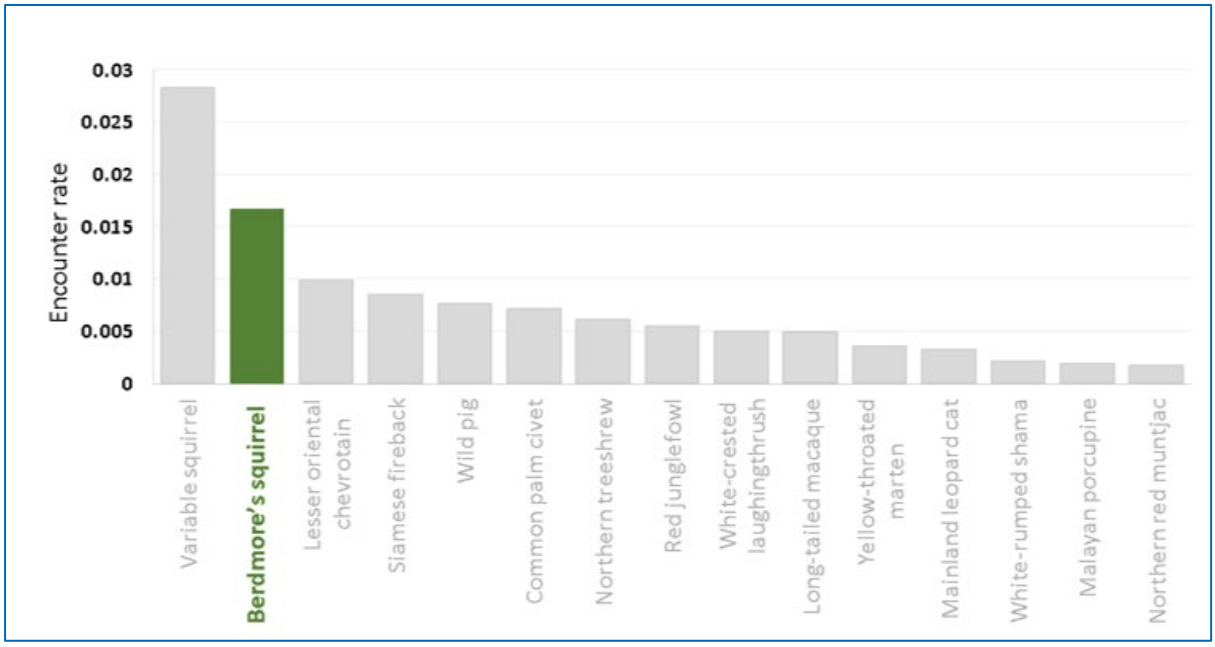

Figure 30: Encounter Rate (Number of Independent Records Divided by the Number of Camera Trap Days) of the Berdmore's Squirrel Compared to Other Wildlife Species

9.2.4 DISTRIBUTION

The Berdmore's ground squirrel is found in Cambodia, Laos, Thailand, Vietnam, Myanmar, and southern China. This species also frequents cultivated areas where large quantities of degraded semi-natural vegetation persist.

In Prey Lang, Berdmore's squirrels are found in high densities near roads in dense forest habitats, as well as in disturbed areas next to Anlong Phe village. This species appears to tolerate habitat degradation well.

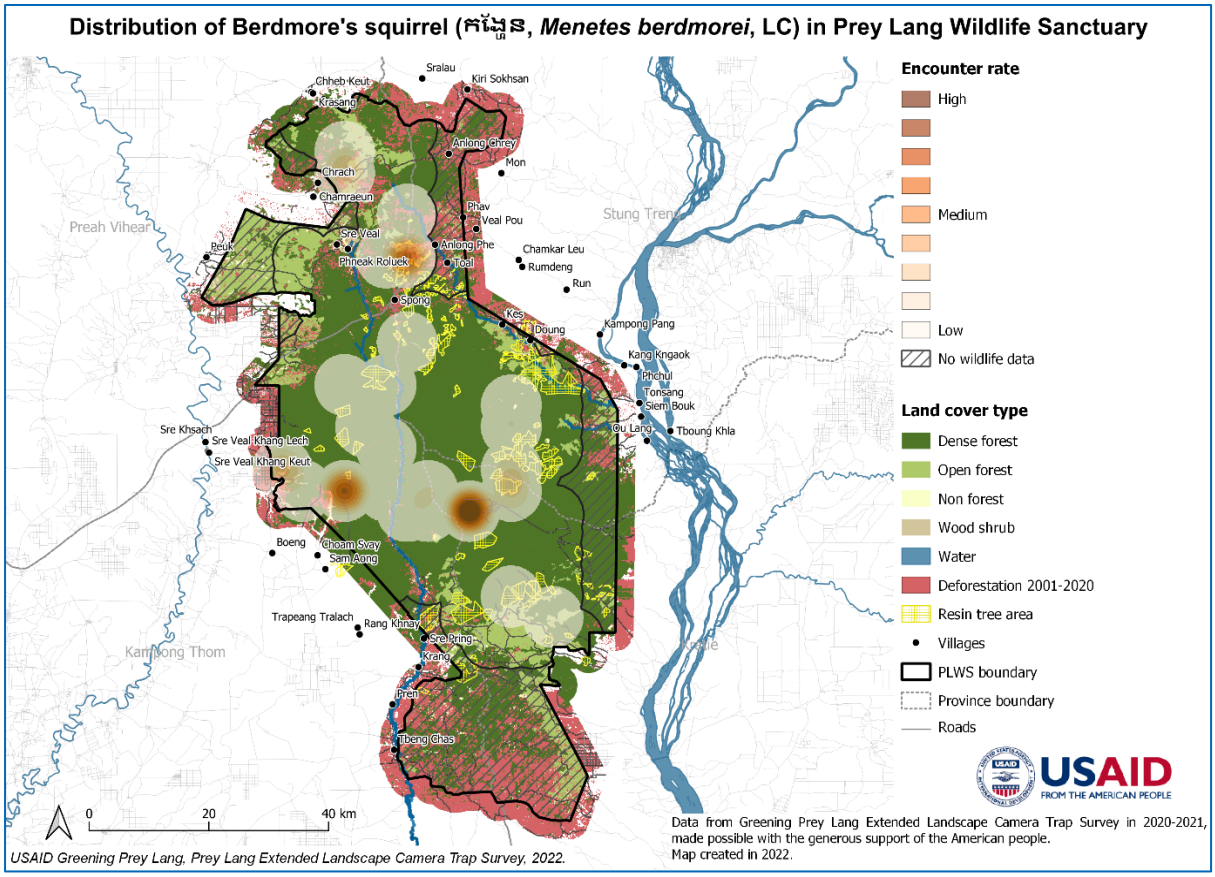

Figure 31: Distribution of Berdmore's squirrel in Prey Lang Wildlife Sanctuary

9.3 NORTHERN TREESHREW (*Tupaia belangeri* - ក្ងីក)

9.3.1 DESCRIPTION

The northern treeshrew is a brown-colored mammal with dark eyes, furless ears, and a large, wet nose. Their long, bushy tail is curved upwards. They are excellent climbers due to their sharp nails and naked pads on their feet. Despite their name, northern treeshrews are more terrestrial than arboreal. They are an omnivorous species, their diet generally consisting of insects and fruits.

9.3.2 ACTIVITY PATTERN

In Prey Lang, the northern treeshrew is a diurnal species, with a peak of activity in the early morning.

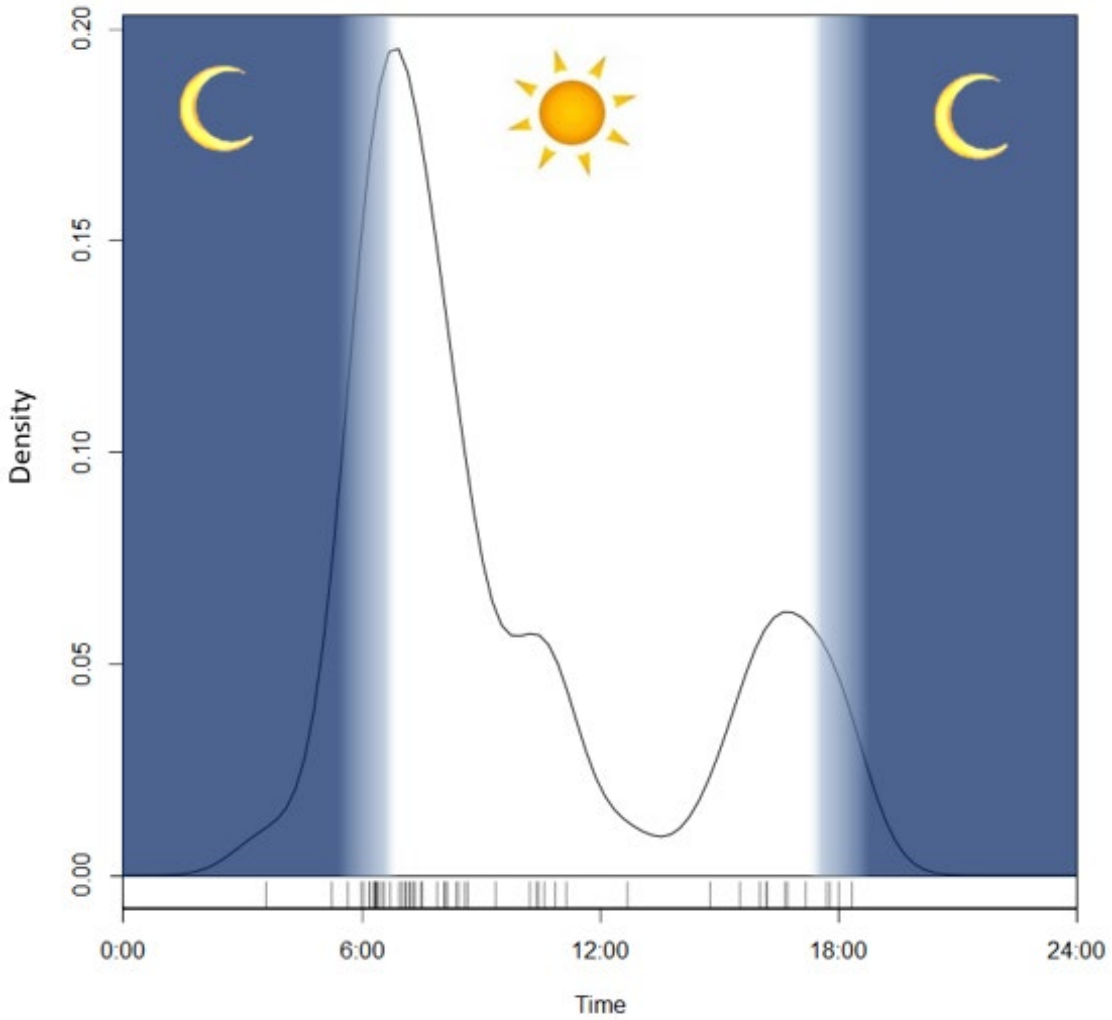

Figure 32: Activity Pattern of the Northern Treeshrew in Prey Lang

9.3.3 POPULATION

The northern treeshrew is common and widespread throughout its range, but no overall population estimate is available. Currently, this species is classified as Least Concern due to its wide range and abundance as well as tolerance to habitat disturbance.

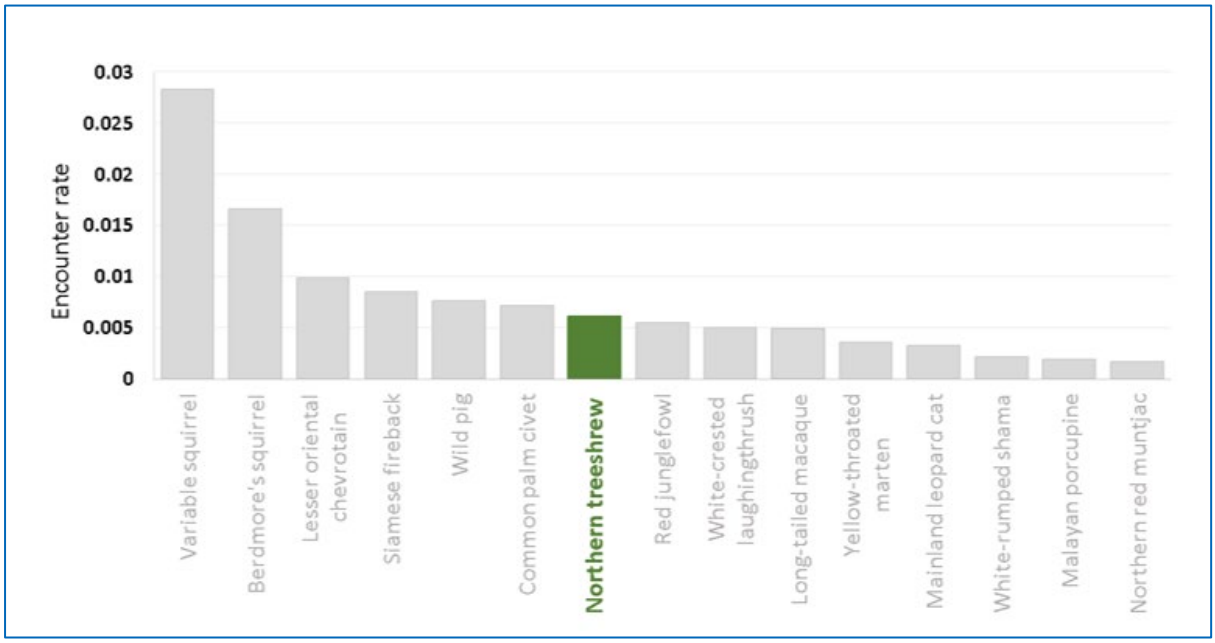

Figure 33: Encounter Rate (Number of Independent Records Divided by the Number of Camera Trap Days) of the Northern Treeshrew Compared to Other Wildlife Species

9.3.4 DISTRIBUTION

The northern treeshrew appears in many parts of mainland Southeast Asia and beyond, including most of Thailand, Myanmar, Cambodia, Laos, and Vietnam. This species lives in a range of habitats, including deciduous primary forests and secondary forests, as well as in disturbed habitats, including palm-oil and coconut plantations.

In Prey Lang, northern treeshrews occur at a high density near Chrach village in a disturbed area, and in a lower density in edge habitat forests on the west side of the protected area.

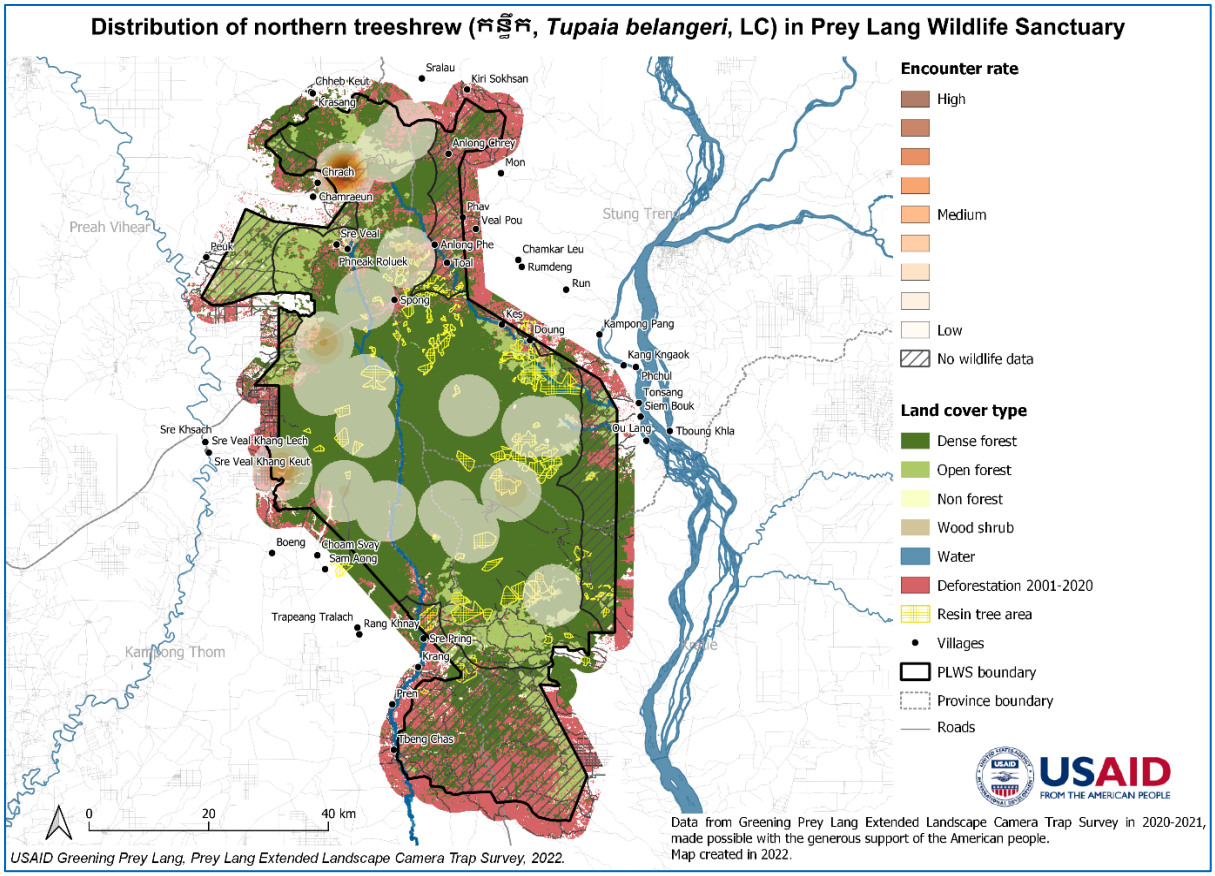

Figure 34: Distribution of Northern Treeshrew in Prey Lang Wildlife Sanctuary

9.4 MALAYAN PORCUPINE (*Hystrix brachyura* - [illegible])

9.4.1 DESCRIPTION

Malayan porcupines are large rodents covered with sharp quills that are modified hair. The quills on their upper body parts are rough with black, white, or yellow stripes. They often inhabit dens near rocky areas or in the holes of trees or root systems. They may also dig out and live in burrows. They are herbivores, feeding mostly on roots, tubers, bark, and fallen fruits.

9.4.2 ACTIVITY PATTERN

In Prey Lang, the Malayan porcupine is an exclusively nocturnal species, with a peak of activity in the late evening.

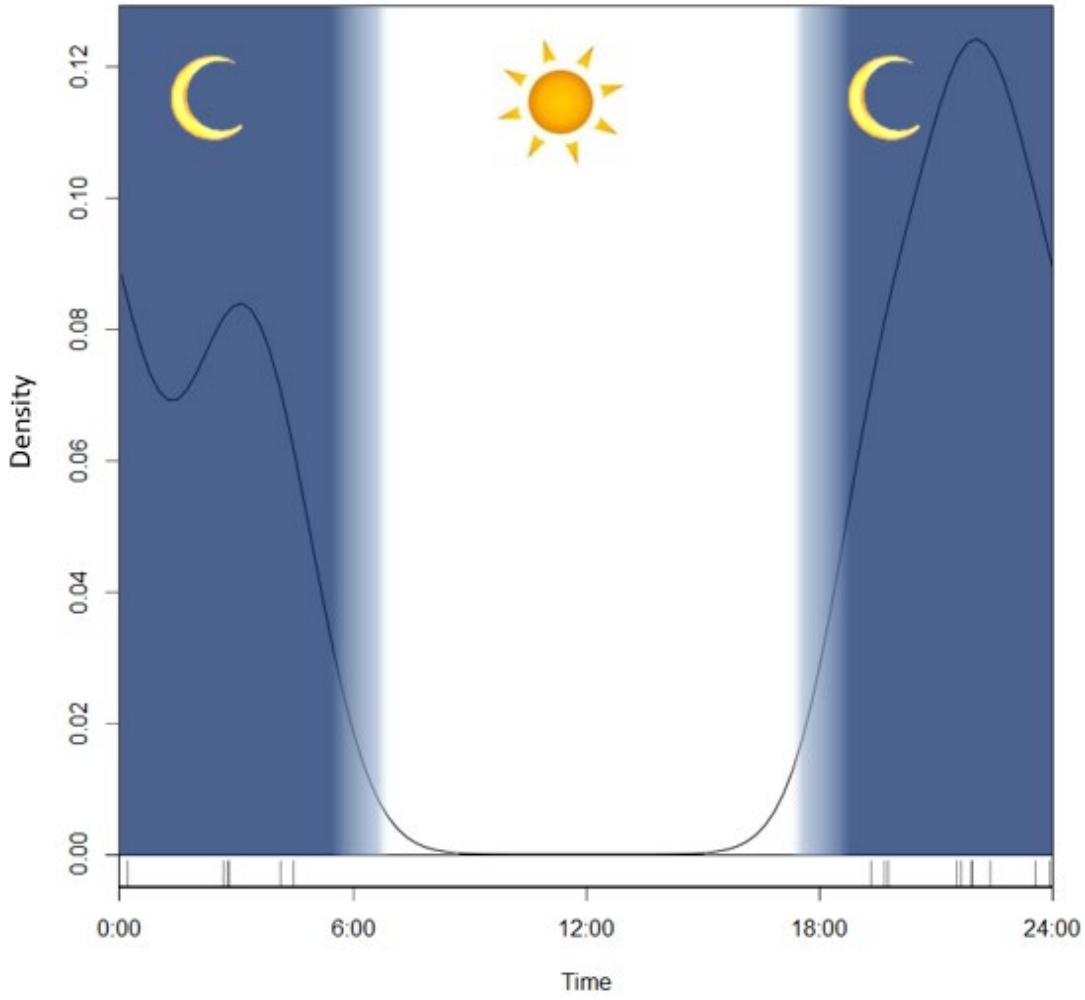

Figure 35: Activity Pattern of the Malayan Porcupine in Prey Lang

9.4.3 POPULATION

The Malayan porcupine has a wide distribution, appearing in several protected areas and is tolerant to habitat modifications. However, in Southeast Asia, it is hunted for subsistence, food, and medicinal purposes.

In Prey Lang, Malayan porcupines are a commonly captured and traded animal for meat and traditional medicine. Hunters usually use snares, dogs, and homemade guns to kill porcupines throughout the protected area.

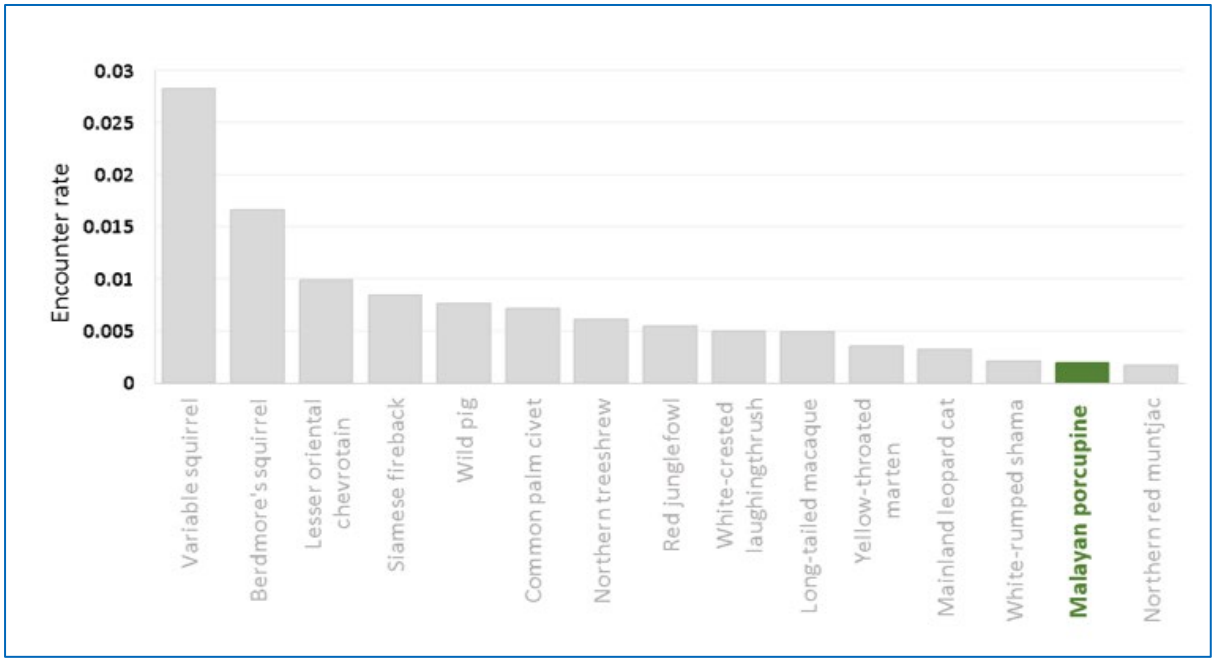

Figure 36: Encounter Rate (Number of Independent Records Divided by the Number of Camera Trap Days) of the Malayan Porcupine Compared to Other Wildlife Species

9.4.4 DISTRIBUTION

This species distribution ranges across Nepal, northeastern India, central and southern China, Cambodia, Myanmar, Thailand, Laos, Vietnam, Peninsular Malaysia, Singapore, Sumatra, and Borneo. This species lives in various types of forest habitats as well as open areas near forests. It can also be found in agricultural areas.

In Prey Lang, Malayan porcupines are seen at a high density along the river in the central evergreen and semi-evergreen forests and along roads in the southern part of Prey Lang.

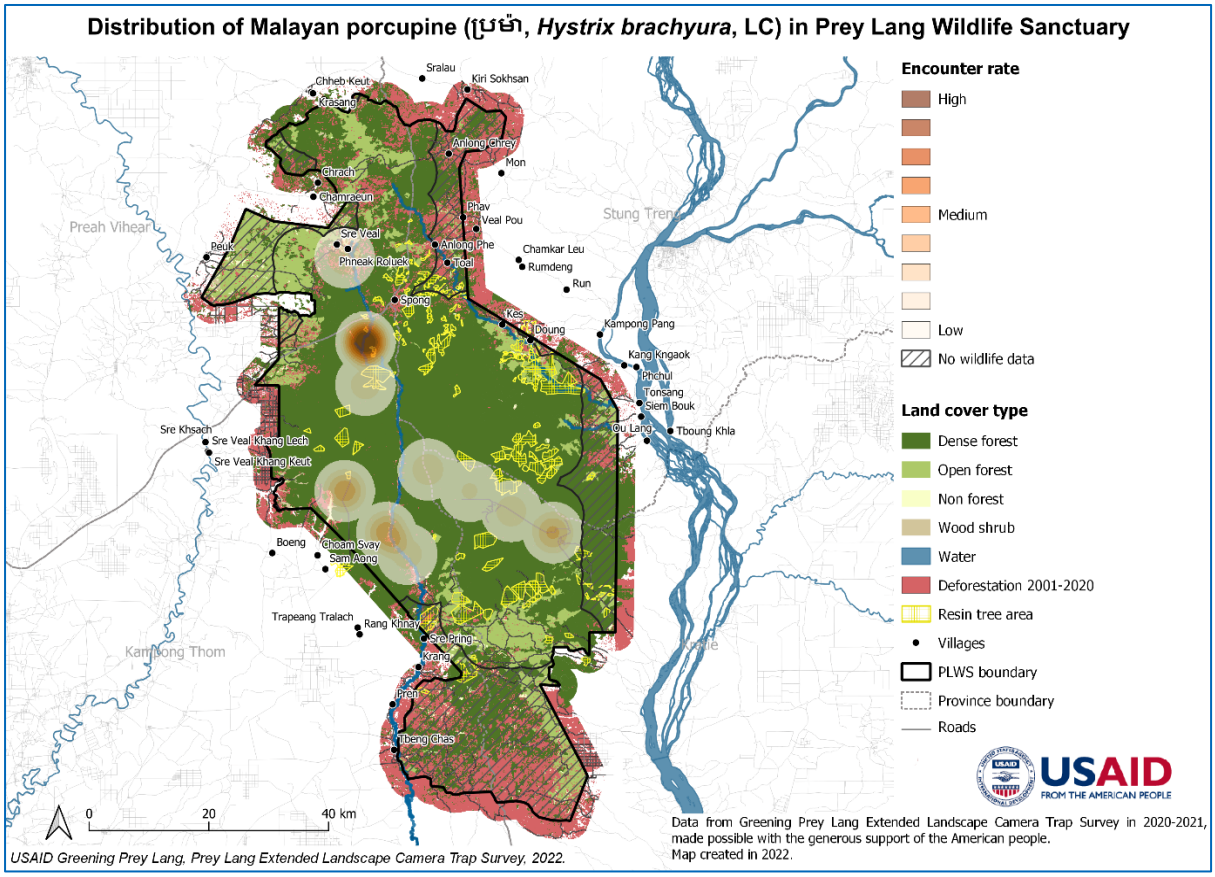

Figure 37: Distribution of Malayan Porcupine in Prey Lang Wildlife Sanctuary

10.0 BIRDS

In Prey Lang, researchers recorded a total of 266 bird species during the last biodiversity assessment conducted in 2014–2015 (Hayes et al. 2015). During this survey, 34 were recorded on camera traps (see Appendix 2). This camera trap survey was targeted at terrestrial species and therefore only mentions ground-dwelling bird species. The research team recorded a total of three terrestrial bird species: Siamese fireback (*Lophura diardi*), red junglefowl (*Tamiops rodolphii*), and green peafowl (*Pavo muticus*).

However, the green peafowl occurs at such low density that it is not possible to produce spatial distribution estimates.

34 bird species recorded on camera trap

1 of them considered as **Endangered** on the IUCN Red list:

- Green peafowl – ក្ងោក

1 Population estimate available

Additional distribution maps for white-crested laughingthrush (*Garrulax leucolophus*) and white-rumped shama (*Copsychus malabaricus*) can be found in Appendix 3 and 4.

Red junglefowl

10.1 SIAMESE FIREBACK (*Lophura diardi* - ស្តេចក្ងាលីត)

10.1.1 DESCRIPTION

The Siamese fireback is a large and robust pheasant. The male of this species has a red face and a long crest of purple-black feathers on his head. These birds are called "fireback" because of the bright yellow spot on their backs that stands out on their plumage. This species is omnivore, feeding on fruits and berries, as well as invertebrates.

Male Siamese fireback

Female Siamese fireback

10.1.2 ACTIVITY PATTERN

In Prey Lang, the Siamese fireback is a diurnal species, with peaks of activity in the early morning and at dusk, suggesting a degree of crepuscularity.

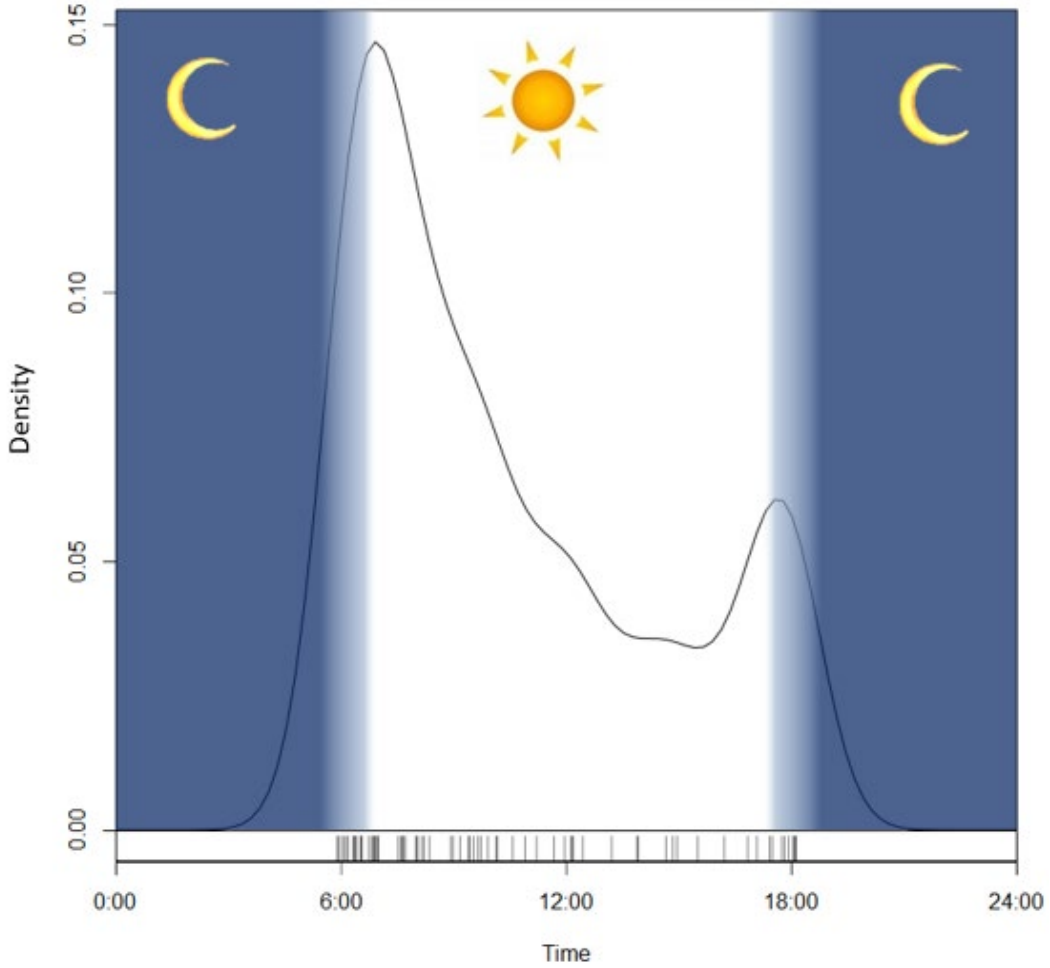

Figure 38: Activity Pattern of the Siamese Fireback in Prey Lang

10.1.3 POPULATION

The Siamese fireback is considered as Least Concern and is common and widespread in Cambodia. The population is suspected of undergoing a slow to moderate decline due to continued habitat loss and degradation and hunting pressure. This species seems able to tolerate considerable degradation of its forest habitat.

During this camera trap survey, the Siamese fireback had the highest encounter rate among the bird species. The population estimate for Siamese fireback populations in Prey Lang is **593 individuals (95% CI 145–1,163)**, equivalent to a density of **0.24 individual per km² (95% CI 0.06–0.48).** This represents the first population estimate for this species in Cambodia. However, this species is targeted by hunters for food and trade, using snares.

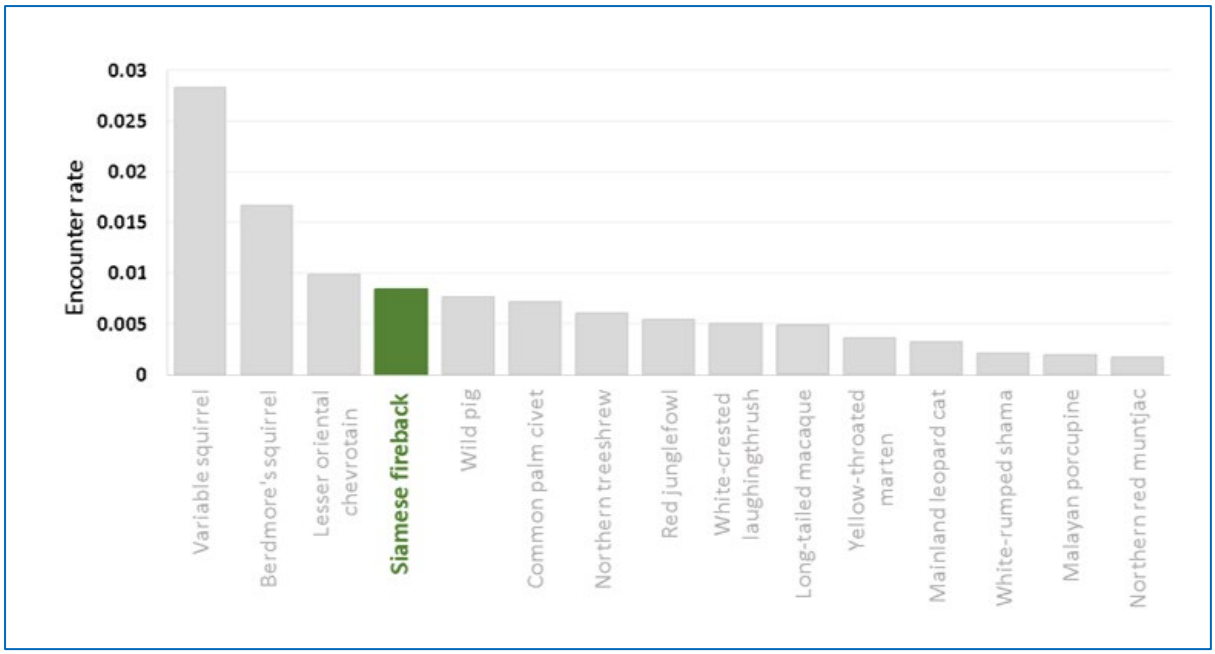

Figure 39: Encounter Rate (Number of Independent Records Divided by the Number of Camera Trap Days) of the Siamese Fireback Compared to Other Wildlife Species

10.1.4 DISTRIBUTION

The Siamese fireback is found in Cambodia, Thailand, Laos, and Vietnam in Southeast Asia. It is seen in evergreen, semi-evergreen, and bamboo forests, along with secondary growth and scrub, often near roads and tracks through the forest.

In Prey Lang, Siamese firebacks are found at a high density near the road leading to Sam Aong village, next to a deforested area. They also appear along the road network on the east side of Prey Lang.

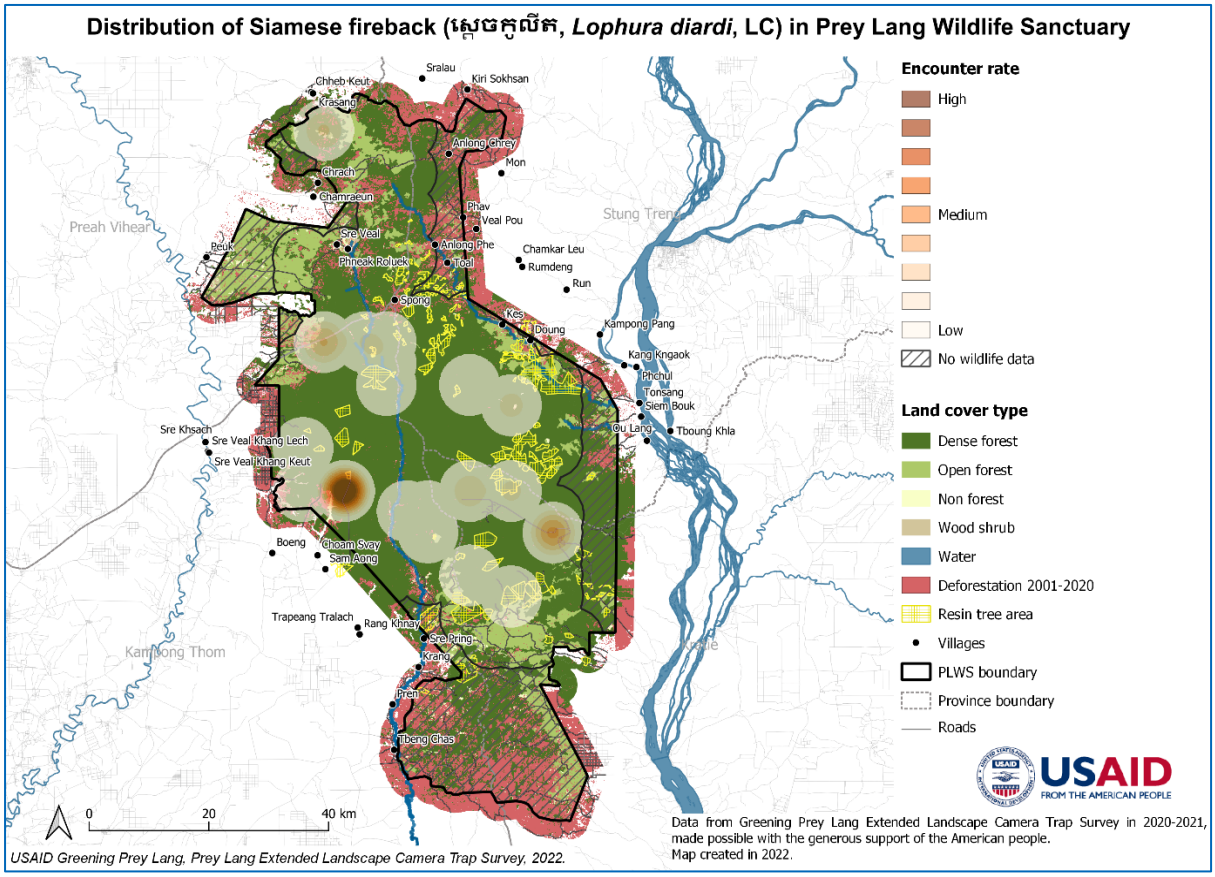

Figure 40: Distribution of Siamese Fireback in Prey Lang Wildlife Sanctuary

10.2 RED JUNGLEFOWL (*Gallus gallus* - មាន់ព្រៃ)

10.2.1 DESCRIPTION

Red junglefowls are social, ground-living birds that typically live in flocks of one to a few males and several females. Male junglefowl are significantly larger than females and have brightly colored, decorative feathers. The male's tail is composed of long, arching feathers that have iridescent green and blue tones. He also has long golden hackle feathers on his neck and on his back. Red junglefowl are omnivores. They feed on fruits, seeds, crops, leaves, roots, and tubers. They also capture a wide variety of arthropods, other invertebrates, and vertebrates such as small lizards. They may even consume mammalian feces.

Male red junglefowl

Female red junglefowl

10.2.2 ACTIVITY PATTERN

The red junglefowl is a diurnal species, with peaks of activity in the early morning and in the late afternoon.

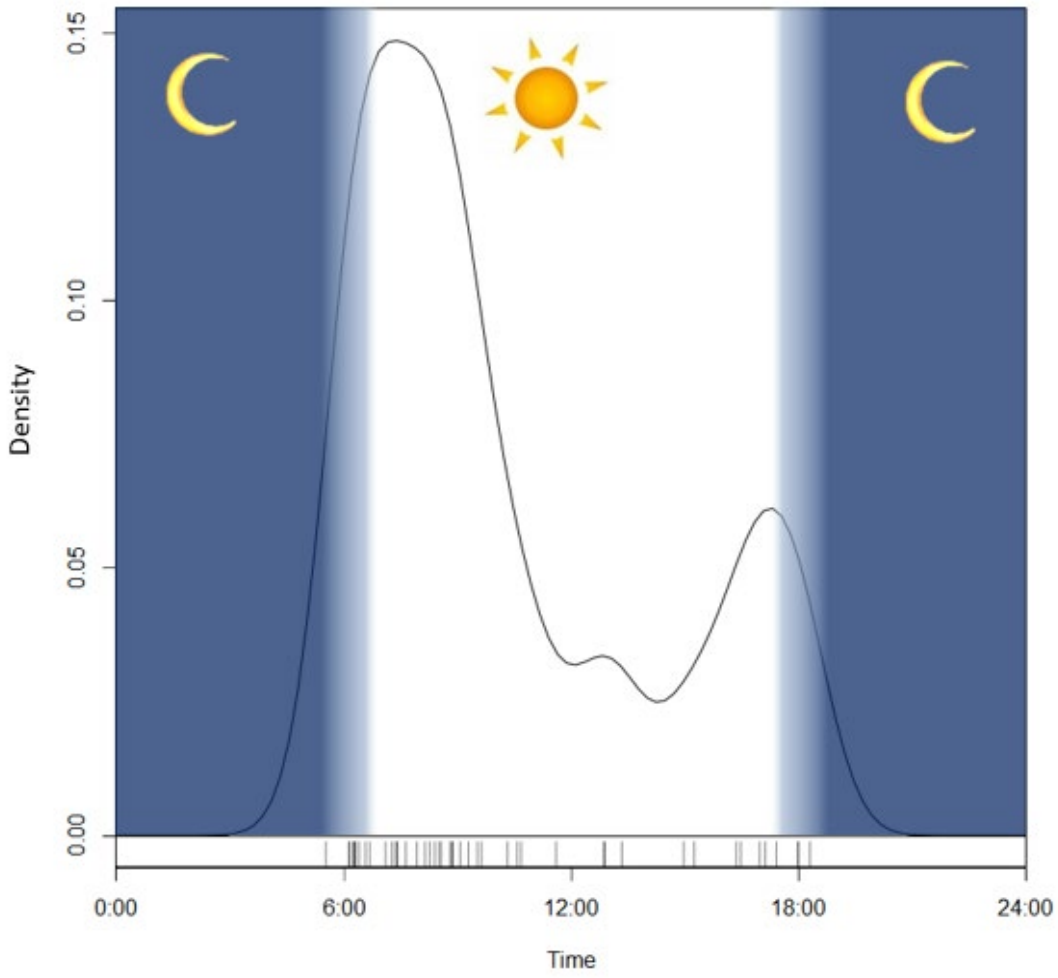

Figure 41: Activity Pattern of the Red Junglefowl in Prey Lang

10.2.3 POPULATION

The red junglefowl is considered as Least Concern, but the global population size has not been quantified. This species is considered common and widespread within their range, but the population trend appears to be decreasing, owing to habitat loss and degradation and over-hunting for food.

During this camera trap survey, the red junglefowl had the second highest encounter rate among birds. This species is hunted for food throughout Prey Lang.

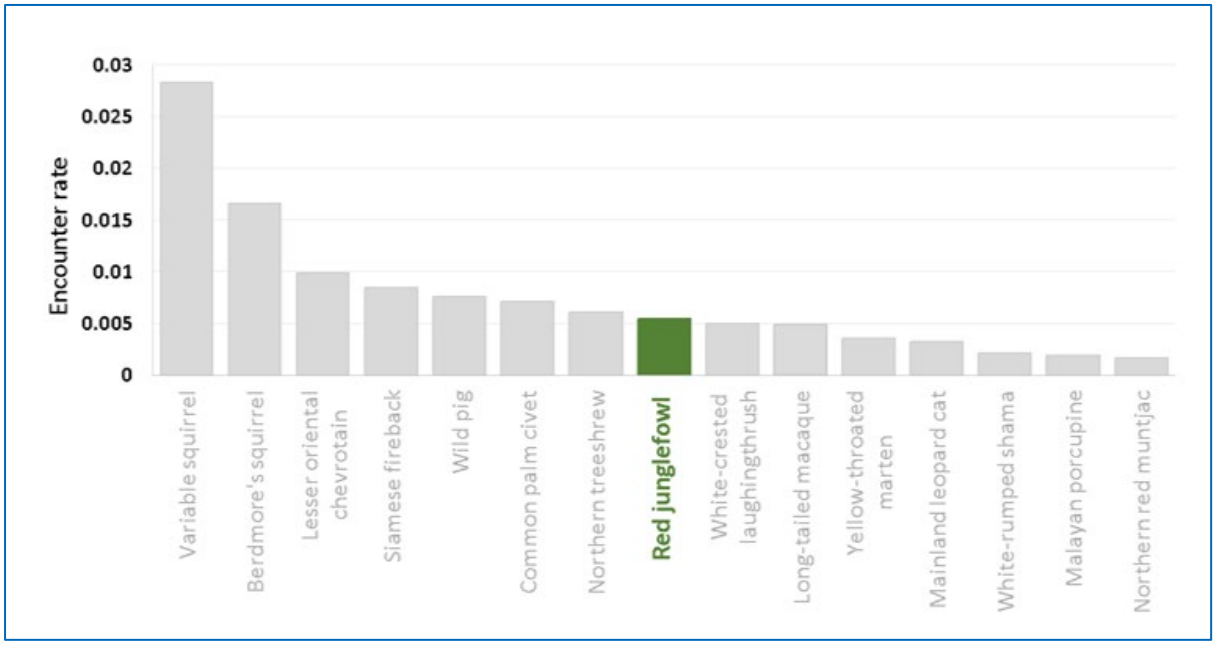

Figure 42: Encounter Rate (Number of Independent Records Divided by the Number of Camera Trap Days) of the Red Junglefowl Compared to Other Wildlife Species

10.2.4 DISTRIBUTION

Red junglefowl range across much of Southeast Asia, including Cambodia, and parts of South Asia. They prefer disturbed habitats and edges, both natural and human-created. These birds can be found in tropical, moist forests; mangroves; scrub areas; tea and palm-oil plantations; and agricultural areas.

In Prey Lang, red junglefowl appear in a higher density along the road network on the east part of the protected area nearby the Mekong River, in dense forest habitats.

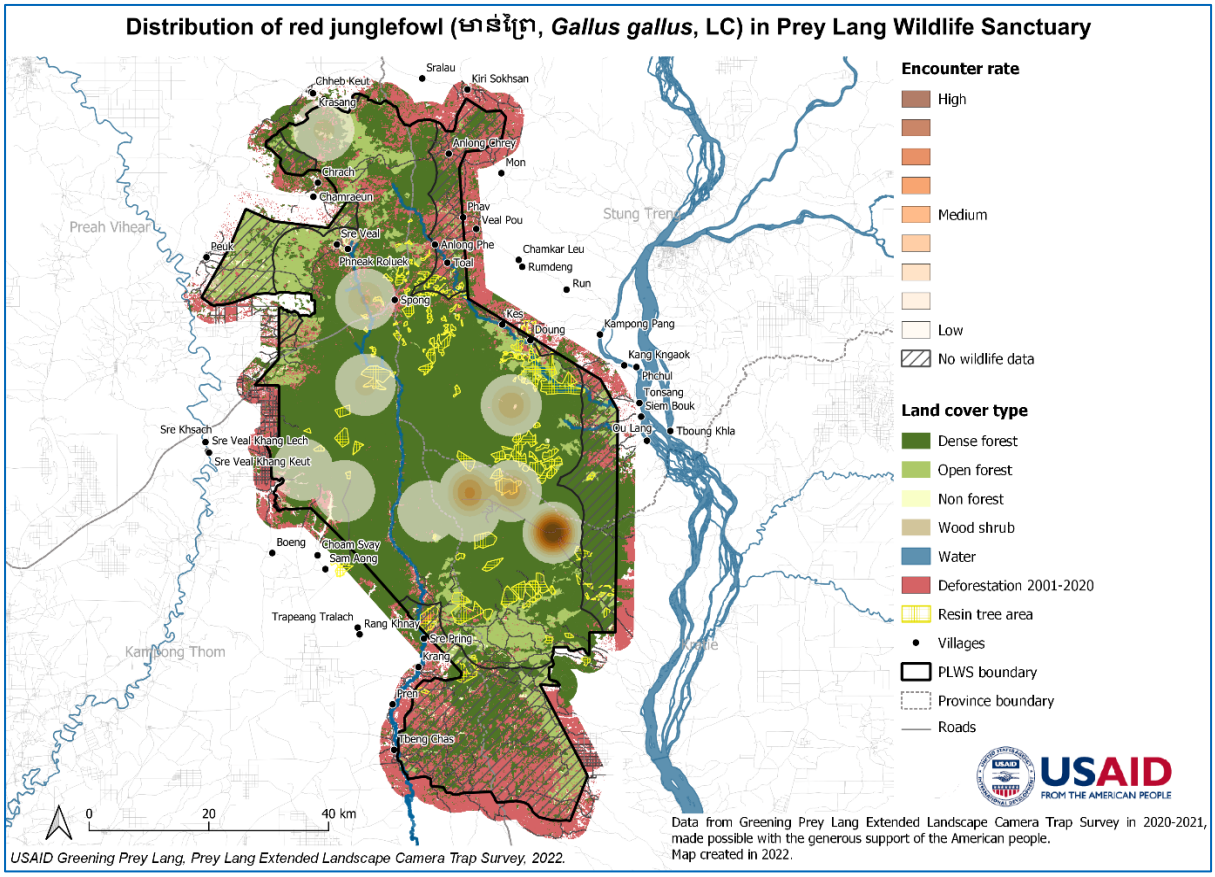

Figure 43: Distribution of Red Junglefowl in Prey Lang Wildlife Sanctuary

11.0 DISCUSSION

This camera trap survey pilot is **the first study in Cambodia to apply camera trap distance sampling** to multiple species over a broad geographic scale. This survey and approach are now established as part of a long-term monitoring program for Prey Lang and will be integrated into the management of the park. During this four-month camera trap survey, the research team recorded a total of **54 species**, including **19 species of mammals**, **34 species of wild birds**, and **1 species of reptile** (see Appendix 2). The team detected a wide variety of wildlife, including rare, nocturnal, and elusive species, and **eight species on the IUCN Red List** (four vulnerable and four endangered species). The team was able to obtain sufficient data to produce **distribution maps and graphical displays of activity patterns** for 13 wildlife species. Despite COVID-19 restrictions preventing the deployment of grid D, the team was still able to produce **population estimates** for four species, as each grid provided complete spatial coverage.

Despite the high initial cost of procuring camera traps, there are **multiple advantages** to monitoring programs using camera traps, in terms of reliability of data gathered and long-term cost efficiency, for example. Camera traps are very efficient for detecting elusive and rare species in difficult forest environments. They are also a cheaper alternative in terms of staff cost and require less effort than line transects. Using camera traps under a distance sampling analytical framework is a robust method to estimate population densities and abundances without the need for individual recognition. In the long term, population estimates will allow **identification of trends and changes** in populations of wildlife species, and distribution estimates will allow for **spatial prioritization**. Furthermore, this methodology broadly targets terrestrial species, allowing data analysis of multiple species with a single data collection methodology. It is based on distance sampling, a well-described and documented theory. Camera trap distance sampling is now a widely used methodology with extensive literature, software, and advice for designing studies as well as analyzing data. Studies suggest that data processing will be less arduous in the future, thanks to recent technological development in automation of species identification (Wildlife Insights n.d.) and distance estimation (Haucke et al. 2022).

Since no previous survey data on encounter rates using camera traps was available for Prey Lang, the team used camera trap results from other protected areas in Cambodia to estimate the effort needed to achieve desired precision for species of interest. Based on the results of this camera trap survey pilot, the team will be able to more precisely calculate the effort required to produce robust population estimates for any key species of this protected area.

For several species, the data collected was insufficient to estimate their distribution and population. As repeated camera trap surveys will yield additional records, it will be possible to **pool data across multiple years** and estimate populations and distributions for **additional species** as well as produce more robust estimates. Furthermore, the team can use this dataset to address other questions, such as studies of occupancy and habitat use. However, some species were rarely detected, for example bear, banteng, and elephant. In these cases, the team should consider other methods, such as **spatially explicit capture-recapture (SECR**), which relies on individual identification. A survey targeted at these species and placement of camera traps in non-random sampling locations might be necessary as well. Arboreal species were also rarely or not detected during this survey, as they tend to spend time outside of the vertical range of camera traps. Therefore, researchers should use **line transects or acoustic surveys** to monitor arboreal primates, such as pileated gibbon or Indochinese silvered langur, which spend little time on the ground.

Camera trap distance sampling provides **standardized and comparable information on wildlife populations and distribution**. The research team managed to estimate an abundance for four species with sufficiently high encounter rates: variable squirrel, Berdmore's squirrel, Siamese fireback, and wild pig. However, comparing abundance estimates with other sites in Cambodia and

neighborhood countries (Thailand, Vietnam, and Laos) is challenging because of the paucity of data and the lack of standardization of monitoring methods.

Monitoring ungulate populations is an **essential part of wildlife management,** with ungulates performing essential ecosystem roles, such as prey for medium-to-large carnivores, seed dispersers, and influencing vegetation patterns. Despite the acknowledged importance of monitoring ungulate populations, there is still **too little information** on tropical ungulate distribution and densities in Southeast Asia obtained using statistically robust survey methodologies. This camera trap distance sampling survey is particularly adapted for medium-sized terrestrial species without unique individual markings. During this survey, a total of five even-toed ungulate species were recorded on camera traps. The team was able to obtain sufficient data to produce distribution maps and graphical displays of activity patterns for half of the even-toed ungulates present in Prey Lang. Sufficient records to model detection functions, and hence estimate density, were only possible for the lesser oriental chevrotain and wild pig. However, it was not possible to produce a reliable population estimate for the lesser oriental chevrotain due to the high variability of the encounter rate. Indeed, only a few cameras produced most detections, resulting in a poor population estimate with low precision. For wild pigs, the estimated population in Prey Lang is **226 individuals (95% CI 97–533)**, equivalent to a density of **0.09 individual per km² (95% CI 0.04–0.22)**. This estimate is significantly lower compared to other landscapes in Cambodia (Gray et al. 2012a); Groenenberg, Crouthers, and Yoganand 2020; Griffin and Nuttall 2020). Wild pigs are likely captured in snares, which are commonly set across Prey Lang. Despite their adaptability, fast reproduction, and lack of significant predators, the high hunting pressure in Prey Lang might impact their population. In other protected areas in Cambodia, the northern red muntjac is considered as widespread and is often one of the most frequently recorded ungulates during previous camera trap surveys (Gray et al. 2012b). Therefore, the low camera trapping rate for northern red muntjac and its restricted and fragmented distribution in Prey Lang found during this survey is highly concerning. This species is normally considered to be robust to hunting and relatively resilient, thus their low encounter rate suggests the hunting pressure on this species is high in Prey Lang and likely significantly impacts their population. Finally, the very low camera trapping rates for sambar and banteng suggest that only small, isolated populations may remain in Prey Lang. The results of this camera trap survey confirm that the **ungulate populations are under severe threats in Prey Lang**, especially hunting with snares and dogs. The low density of these species is serious and alarming, as they play vital ecological roles in the forest ecosystem, and their loss could in turn impact local indigenous communities in Prey Lang, who depend on the forest and its resources for survival.

Population estimates for the two species of squirrels presented in this document are the **first ever obtained in Southeast Asia**. Squirrels are a vital part of the ecosystems as seed dispersers and are also a key food source for many predators. During the survey, camera traps did not record any dholes or golden jackals, despite being recorded during the last biodiversity assessment conducted in 2014–2015 (Hayes et al. 2015). These two mammalian carnivores are keystone species critical to ecosystem function, exerting control over smaller predators, prey, and the plant world. The dhole preferentially feed on small-to-large ungulates, depending on the prey availability in the area. For example, in Peninsular Malaysia, chevrotains represented more than 75% of the dhole diet (Kawanishi and Sunquist 2008). Whereas in Cambodia, dholes appear to feed predominantly on northern red muntjac, followed by wild pig and banteng (Kamler et al 2020). On the other hand, the golden jackal is an extremely adaptable and opportunistic species. It can be both a predator and scavenger, consuming small rodents, wild ungulates, and civets, as well as feeding off the kills made by larger carnivores, such as dholes or leopards. In Cambodia, during the dry season, a relatively high proportion of the jackal diet comprises ungulates, such as muntjacs and wild pigs (Kamler et al 2021). The **management of ungulate populations** in Prey Lang is therefore **vital for the conservation of dhole and jackal populations**. The protected area management authorities should design a survey targeted at large predators, as the disappearance of these two predators can cause a "trophic cascade" and significantly impact many other species, such as causing an increase in herbivore densities, which affects the food web; altering ecosystems; and indirectly impacting human

populations. These consequences include changes in vegetation, wildfire frequency, and infectious diseases.

The Siamese fireback had the fourth highest encounter rate among wildlife species, and the highest encounter rate for bird species. This species is considered as common and relatively abundant in some protected areas in Thailand, Laos, Vietnam, and Cambodia. They appear to be able to tolerate considerable degradation of their forest habitat. However, these tropical pheasants are difficult to survey, due to their cryptic behavior (non-calling bird and inhabiting dense tropical forest) and their lack of unique identification markings. The Siamese fireback population has declined continuously due to habitat degradation and loss as well as hunting. Along with these threats, this species also lacks reliable density estimates. Using camera trap distance sampling, the research team managed to produce distribution and abundance estimates for this terrestrial bird species, with a population estimate in Prey Lang of **593 individuals (95% CI 145–1,163)**, equivalent to a density of **0.24 individual per km² (95% CI 0.06–0.48)**. This is the **first population estimate of this species in Cambodia**. And yet, animal abundance provides the most critical information for defining the status of a species and thus for conservation assessments and practical wildlife management. This camera trap pilot demonstrates the value of camera trap distance sampling for surveying certain species of tropical Asian galliformes in Cambodia, such as Siamese fireback and red junglefowl.

These results were presented to management authorities of Prey Lang to identify areas that should be considered a priority for increased conservation. Furthermore, this pilot provides robust population and distribution estimates, which are **good quality biodiversity indicators** to develop a Reducing Emissions from Deforestation and Forest Degradation (REDD+) project. The Prey Lang Wildlife Sanctuary REDD+ project proponents and implementation team incorporate the findings from this survey into the REDD+ project design and monitoring program.

Despite significant protection efforts, threats continue to cause biodiversity and forest loss, as showed by the unexpected low level of ungulate populations. The protected area management authorities must take significant action in Prey Lang to reduce further decline of terrestrial mammals, by first strongly reducing hunting in the protected area.

12.0 MANAGEMENT RECOMMENDATIONS

The overall vision of the Activity of USAID GPL project is to promote resilient, low-emissions development through inclusive sustainable management of the PLEL. One of the three objectives of this project is to improve biodiversity conservation and ecosystem health in the PLEL. This intensive and novel camera trap survey using a distance sampling approach in Cambodia is fully in line with this objective.

12.1 CAMERA TRAP DISTANCE SAMPLING

Based on the promising results of this camera trap survey, further goals include:

- **Continuing this camera trap survey program every three or four years** following the standardized methodology established as part of the GPL project. This first-year camera trap pilot showed that camera trap distance sampling is an effective method to produce baseline estimates of distribution and abundance for multiple species, information urgently needed for conservation planning and action. Once further surveys are repeated, it will be possible to pool data across multiple years and estimate population and distribution for additional species. In the long term, this methodology will allow researchers to obtain reliable estimates of the abundance for several species, provide sufficient precision to detect strong trends, and inform protected area management. Distribution estimates will be more precise after each camera trap survey, supporting spatial prioritization and zoning process.
- **Estimating the effort needed to achieve desired precision for species of interest** for the next camera trap survey based on the results of this first camera trap pilot.
- **Considering other methodologies** for species for which it is particularly challenging to produce distribution and population estimates due to rarity or semi-arboreal behavior. Researchers have used line transect surveys in Prey Lang specifically targeted at primates to estimate their abundance. Moreover, other potential approaches, using different methodologies such as more targeted camera trapping, will be considered as well.
- **Ensuring a technological watch on new emerging technologies** concerning camera trap data processing, such as automation of species identification using artificial intelligence and automation of distance estimation.
- **Producing a toolkit of standardized methodologies more widely available first in Cambodia** and then more globally, to adequately monitor population of terrestrial species over time and space. With this toolkit, the different sites would be able to choose and apply the most appropriate methodology based on local requirements.

12.2 LAW ENFORCEMENT

Along with additional camera trap surveying, the involvement of law enforcement strategies is crucial to the well-being of the PLEL, including:

- **Improving law enforcement strategy and implementation** through targeting actions. This data helps to identify key areas of biodiversity importance which rangers and protected area management authorities can prioritize for patrolling, therefore increasing patrol effectiveness. Based on the results of this pilot, efforts must concentrate on improving and increasing anti-poaching actions, as hunting has proven difficult to stop through conventional protected area law enforcement approaches.
- **Reducing demand of wildlife** nationally and internationally to effectively combat hunting. The commercial trade of wildlife for consumption is a key underlying driver of hunting. Conservation practitioners and government agencies responsible for biodiversity

conservation should consider developing demand reduction campaigns focused on diminishing the purchase of wildlife by directly targeting consumers.

12.3 THREAT REDUCTION

Lastly, threat reduction tactics can help preserve the PLEL landscape by:

- **Using the results of this biodiversity monitoring to inform law enforcement strategy.** The results of this pilot, such as the distribution maps, will be used to inform law enforcement strategy. For example, reducing the use of snares and homemade and conventional guns will help lessen poaching, a major threat for several species, especially ungulates.
- **Addressing illegal forest clearances** to decrease threats to key species. This is largely driven by land speculation and ultimately for agricultural use. Tackling this issue requires significant work from the governance perspective, getting all involved stakeholders to understand that this is not only a threat for various species, but it will also impact the communities living in Prey Lang. It could also increase their vulnerability to natural disasters, food insecurity, and emergence or resurgence of zoonotic diseases. Additionally, a more ambitious collaboration at the national and international levels is needed to make necessary changes to increase demands of deforestation-free commodities by markets.
- **Reducing threats to wildlife from dogs.** This domestic species had the fifth highest encounter rate during this camera trap survey, ranging just above wild pigs. Based on the distribution map of domestic dogs (see Appendix 6), these wildlife threats tend to occur close to villages as expected, but also in the central evergreen and semi-evergreen forests of Prey Lang. Their distribution overlapped key areas of biodiversity identified in the east of the protected area and are also found in areas where no traditional use of the forest was identified. Many dogs appear to be free roaming in the protected area, significantly impacting wildlife through hunting and transferring diseases.
- **Mitigating the impact of the powerline construction on biodiversity and monitoring the impact on the biodiversity distribution and population.** Transmission lines can cause significant impacts on the environment both during the construction and operation phases. The distribution maps can be used to mitigate the impact of the powerline construction and operation on biodiversity. This new powerline may lead to population fragmentation for several species, as shown on the species richness distribution map (see Appendix 5). Continuing this camera trap survey program will allow researchers to monitor the impact of this powerline on the population and distribution of biodiversity to inform management decisions.

13.0 CONCLUSION

This camera trap survey pilot in Cambodia using camera trap distance sampling methodology efficiently provides baseline estimates on population and distribution of multiple terrestrial species in Prey Lang. This is the first step toward a long-term biological monitoring program using camera traps in Prey Lang. These results provide further support that Prey Lang Wildlife Sanctuary is a site of high importance for biodiversity, recording a total of 54 species during this first survey and documenting eight species on the IUCN Red List.

Despite Prey Lang existing as a large and mostly intact forest landscape, hunting has severely impacted the populations of terrestrial mammals. This critically important issue needs immediate action, and the Prey Lang Wildlife Sanctuary must adopt new measures to allow species to recover in this landscape and avoid extirpation. While illegal hunting clearly requires law enforcement action on the ground, addressing the actual underlying drivers of hunting, the market demand, entails a different approach. The survey results clearly indicate that significant efforts and resources must be immediately allocated to eliminate the market demand for wildlife both nationally and internationally.

Reliable estimates of terrestrial species density and abundance are essential for effective wildlife conservation and management. This camera trap methodology will be added to the toolkit of methodologies available in Cambodia to accurately estimate terrestrial species population. While the highly standardized approach has some impact on reducing captures of some rare and elusive species, or those with very specific habitat usage, the overall output of this pilot is a very rigorous and robust assessment of terrestrial mammals in the landscape. The research team should consider other methodologies to estimate the density of rare or semi-arboreal species. For example, for rare but individually recognizable individuals, it may be preferable to deploy camera traps in non-random locations to obtain sufficient detections to estimate density by SECR.

Other sites in Cambodia where Conservation International and the Wildlife Conservation Society work are replicating the approach used during this survey, and it is now part of the long-term biodiversity monitoring of Prey Lang and protected areas in the Northern Plains Landscape in Preah Vihear for understanding the impact of threats to wildlife, improving protected area management, and reporting for REDD+.

Training on distance reference video, 2020

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APPENDICES

APPENDIX 1: INTERNATIONAL UNION FOR CONSERVATION OF NATURE RED LIST STATUS 2023

Table 3: Number of Species in Prey Lang Recorded during This Camera Trap Survey, Assessed and Classified as Threatened (CR, EN, and VU) on the International Union for Conservation of Nature (IUCN) Red List Status of 2023

	IUCN Red List Status 2023							
	CR	EN	VU	NT	LC	DD	NE	Total
Mammals	0	3	4	0	12	0	0	**19**
Birds	0	1	0	0	33	0	0	**34**
Reptiles	0	0	0	1	0	0	0	**1**
Total	0	4	4	1	45	0	0	**54**

CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: Near Threatened, LC: Least Concern, DD: Data Deficient, and NE: Not Evaluated.

APPENDIX 2: SUMMARY OF WILDLIFE SPECIES

Table 4: Summary of Wildlife Species Recorded during the Camera Trap Survey in Prey Lang Wildlife Sanctuary

Class	Species	IUCN Status	Distribution Map	Abundance Estimate
Mammal	Long-tailed macaque ស្វាក្តាម *Macaca fascicularis*	EN	Yes	No
Mammal	Banteng ទន្សោង *Bos javanicus*	EN	No	No
Mammal	Sambar ប្រើស *Rusa unicolor*	VU	No	No
Mammal	Lesser oriental chevrotain ក្តាន់ញ្ជែងតូច *Tragulus kanchil*	LC	Yes	Yes
Mammal	Northern red muntjac ឈ្លូស *Muntiacus vaginalis*	LC	Yes	No
Mammal	Wild pig ជ្រូកព្រៃ *Sus scrofa*	LC	Yes	No
Mammal	Asian elephant ដំរីអាស៊ី *Elephas maximus*	EN	No	No
Mammal	Sun bear ខ្លាឃ្មុំតូច *Helarctos malayanus*	EN	No	No
Mammal	Asiatic black bear ខ្លាឃ្មុំធំ *Ursus thibetanus*	VU	No	No

Class	Species	IUCN Status	Distribution Map	Abundance Estimate
Mammal	Binturong សំពោចភ្នំ *Arctictis binturong*	VU	No	No
Mammal	Common palm civet សំពោចក្រអូប *Paradoxurus hermaphroditus*	LC	Yes	No
Mammal	Leopard cat ឆ្មាដាវ *Prionailurus bengalensis*	LC	Yes	No
Mammal	Small Indian civet សំពោចវល្លិ *Viverricula indica*	LC	No	No
Mammal	Yellow-throated marten សំពោចកលឿង *Martes flavigula*	LC	Yes	No
Mammal	Berdmore's squirrel កង្ហែន *Menetes berdmorei*	LC	Yes	Yes
Mammal	Cambodian striped squirrel កង្ហិចកម្ពុជា *Tamiops rodolphii*	LC	No	No
Mammal	Variable squirrel កំប្រុកពណ៍ *Callosciurus finlaysonii*	LC	Yes	Yes
Mammal	Northern treeshrew កន្ទឹក *Tupaia belangeri*	LC	Yes	No
Mammal	Malayan porcupine ប្រម៉ា *Hystrix brachyura*	LC	Yes	No
Bird	Siamese fireback ស្តេចកូលីត *Lophura diardi*	LC	Yes	Yes
Bird	Red junglefowl មាន់ព្រៃ *Gallus gallus*	LC	Yes	Yes
Bird	Green peafowl ក្ងោក *Pavo muticus*	EN	No	No
Bird	Shikra ស្នាំងស្លាបឆែក *Accipiter badius*	LC	No	No
Bird	Besra ស្នាំងស្លាបឆែកព្រៃ *Accipiter virgatus*	LC	No	No
Bird	Changeable hawk-eagle អកព្រៃច្រើនពណ៍ *Nisaetus cirrhatus*	LC	No	No
Bird	Crested serpent-eagle អកពស់ព្រៃ *Spilornis cheela*	LC	No	No

Class	Species	IUCN Status	Distribution Map	Abundance Estimate
Bird	Oriental pied hornbill កេងកងតូច *Anthracoceros albirostris*	LC	No	No
Bird	Emerald dove លលកស្លាបបៃតង *Chalcophaps indica*	LC	No	No
Bird	Banded kingfisher កដបព្រៃ *Lacedo pulchella*	LC	No	No
Bird	Indian roller ទៀរ *Coracias affinis*	LC	No	No
Bird	Greater coucal ល្អូតធំ *Centropus sinensis*	LC	No	No
Bird	Chestnut-winged cuckoo តារៀកំប៉ោយ *Clamator coromandus*	LC	No	No
Bird	Scaly-breasted partridge ទទាជើងបៃតង *Tropicoperdix chloropus*	LC	No	No
Bird	Bronzed drongo អន្ទេបខ្មៅផ្លេក *Dicrurus aeneus*	LC	No	No
Bird	White-crested laughingthrush ចកវ៉ក *Garrulax leucolophus*	LC	Yes	No
Bird	Lesser necklaced laughingthrush ចកវ៉កវ័ណ្ឌទ្រូងខ្មៅ *Garrulax monileger*	LC	No	No
Bird	Black-naped monarch ចាបស្ងក៏ខៀរ *Hypothymis azurea*	LC	No	No
Bird	Blyth's paradise-flycatcher ចាបស្ងក៏អាស៊ី *Terpsiphone affinis*	LC	No	No
Bird	White-rumped shama ល្វាចេកព្រៃ *Copsychus malabaricus*	LC	Yes	No
Bird	Blue-and-white flycatcher ចាបស៊ីរុយធំខៀរស *Cyanoptila cyanomelana*	LC	No	No
Bird	Indochinese blue-flycatcher ចាបស៊ីរុយចង្កាលឿងស្លាបខ្លី *Cyornis sumatrensis*	LC	No	No
Bird	White-throated rock thrush ពពេចថ្មបំពង់កស *Monticola gularis*	LC	No	No
Bird	Crimson sunbird ចាបកន្លង់ក្រហម *Aethopyga siparaja*	LC	No	No

Class	Species	IUCN Status	Distribution Map	Abundance Estimate
Bird	Abbott's babbler ចាបព្រៃចំពុះធំ *Malacocincla abbotti*	LC	No	No
Bird	Scaly-crowned babbler ចាបព្រៃបន្ទូលក្បាលស្រកា *Malacopteron cinereum*	LC	No	No
Bird	Puff-throated babbler ចាបព្រៃបំពង់កប៉ោង *Pellorneum ruficeps*	LC	No	No
Bird	Pale-legged or Sakhalin leaf warbler ចាបស្លឹកជើងព្រៃលៃត *Phylloscopus tenellipes or borealoides*	LC	No	No
Bird	Puff-throated bulbul ពពេចធំបំពង់កប៉ោង *Alophoixus pallidus*	LC	No	No
Bird	Stripe-throated bulbul ពពេចពុកមាត់លឿង *Pycnonotus finlaysoni*	LC	No	No
Bird	Cattle egret កុកគោ *Bubulcus ibis*	LC	No	No
Bird	Greater yellownape ត្រសេះកំប៉ោយលឿងធំ *Chrysophlegma flavinucha*	LC	No	No
Bird	Laced woodpecker ត្រសេះបៃតងក្បាលក្រហម *Picus vittatus*	LC	No	No
Bird	Orange-breasted trogon ចាបជៀបលឿង *Harpactes oreskios*	LC	No	No
Reptile	Bengal monitor ត្រកួត *Varanus bengalensis*	NT	No	No

CR: Critically Endangered, EN: Endangered, VU: Vulnerable, NT: Near Threatened, LC: Least Concern, DD: Data Deficient, and NE: Not Evaluated.

APPENDIX 3: DISTRIBUTION OF WHITE-CRESTED LAUGHINGTHRUSH

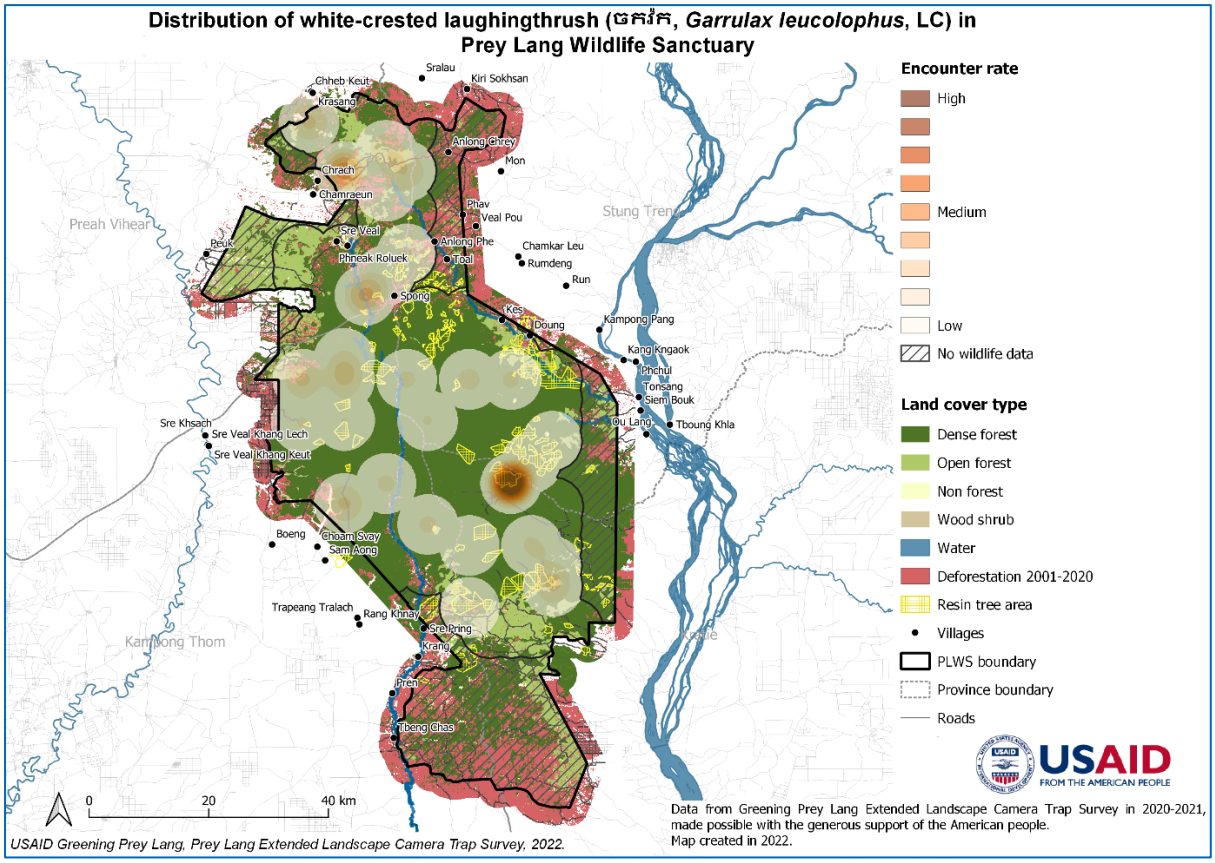

Figure 44: Distribution of White-Crested Laughingthrush in Prey Lang Wildlife Sanctuary

APPENDIX 4: DISTRIBUTION OF WHITE-RUMPED SHAMA

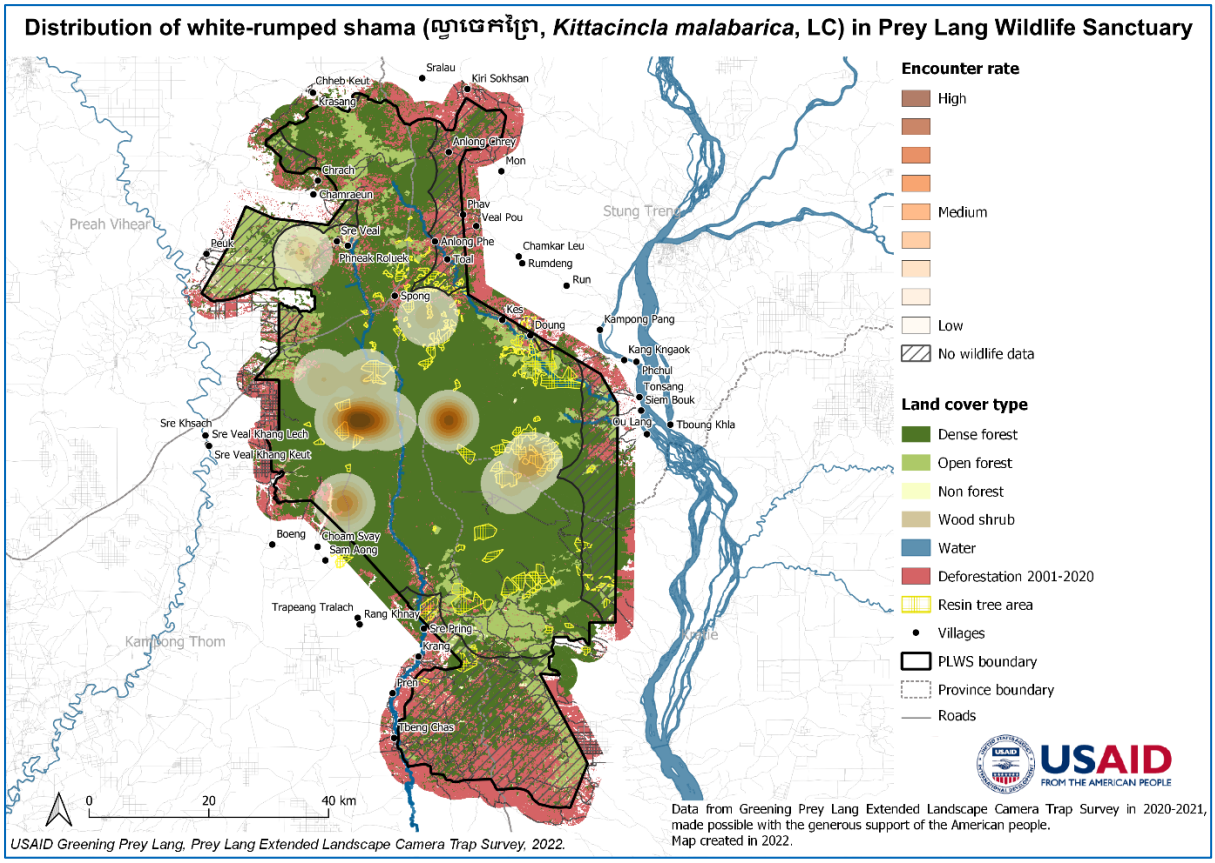

Figure 45: Distribution of White-Rumped Shama in Prey Lang Wildlife Sanctuary

APPENDIX 5: SPECIES RICHNESS IN PREY LANG WILDLIFE SANCTUARY

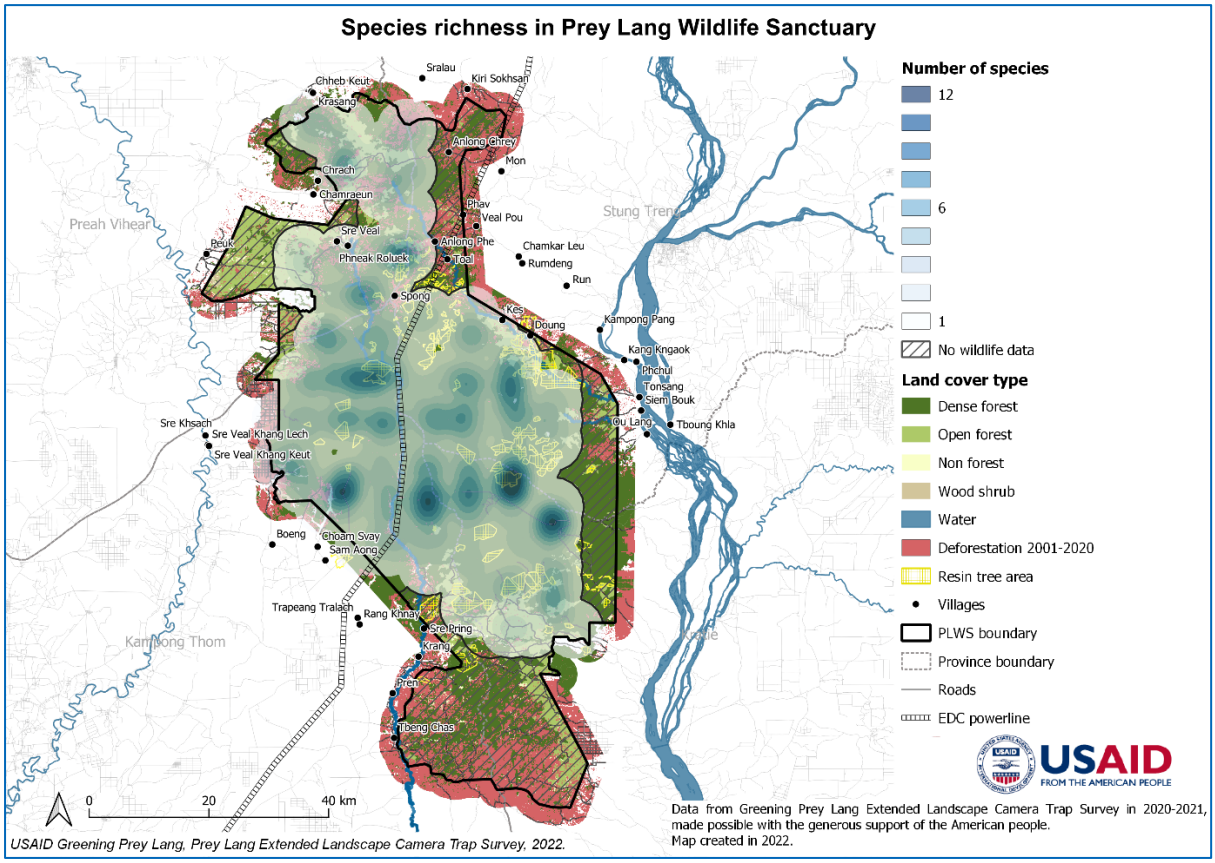

Figure 46: Distribution Map Representing the Species Richness in Prey Lang with the Planned Route for the *Electricite du Cambodge* (EDC) Powerline Added

APPENDIX 6: DISTRIBUTION OF DOMESTIC DOGS

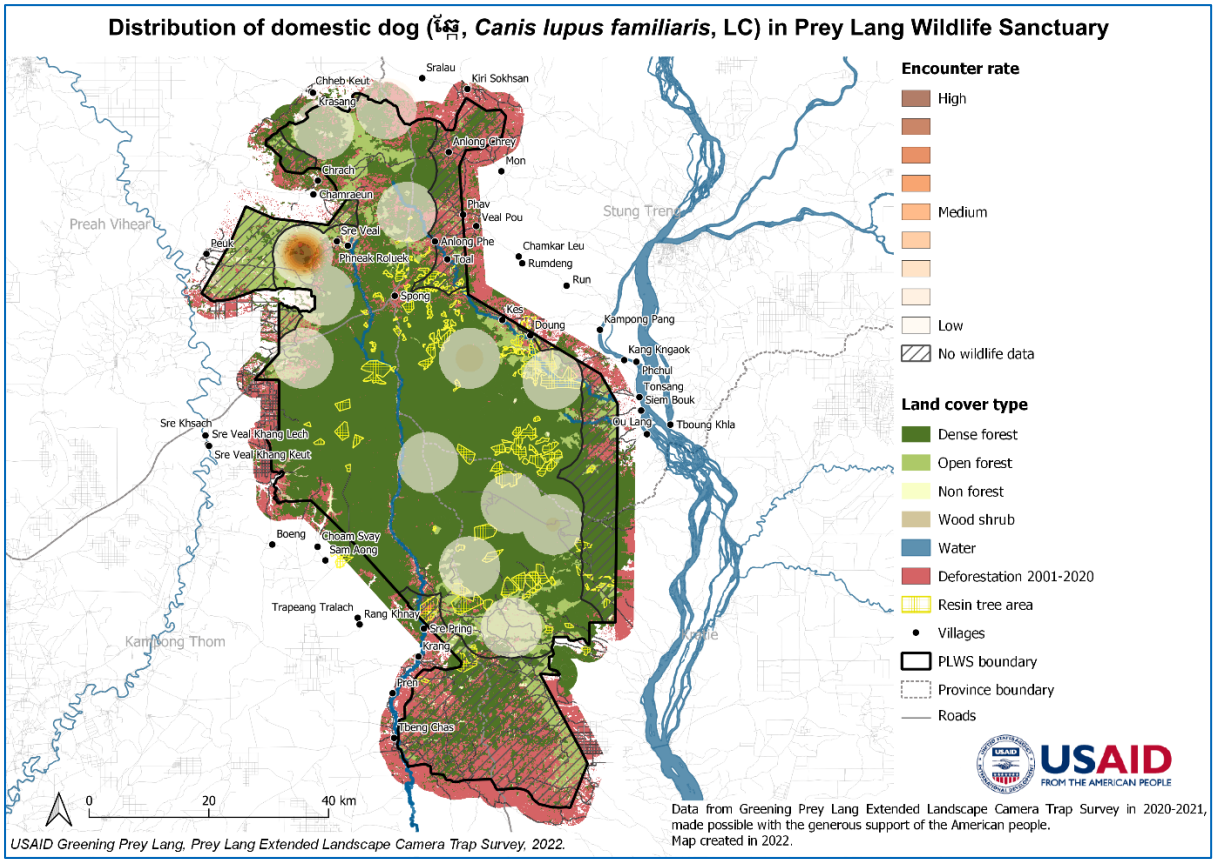

Figure 47: Distribution of Domestic Dogs in Prey Lang Wildlife Sanctuary